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THE RONEY MECHANICAL STOKER AND SMOKELESS FURNACE.

THE Roney mechanical stoker is a simple apparatus, which, when attached to steam boilers, receives the fuel in bulk, and thereafter, without further handling, feeds it continuously, and at any desired rate, to the furnace, burns the combustible portion, and deposits the ash and cinder in the ash pit ready for removal.

The fuel to be burned is dumped into the hopper on the boiler front. In small plants it may be shoveled in by hand. In large plants it is usually handled direct from the car to the hopper by elevators and conveyers. Set in the lower part of the hopper is a pusher (see Fig. 2), to which is attached, by a flexible connection, the feed plate forming the bottom of the hopper. The pusher, by a vibratory motion, carrying with it the feed plate, gradually forces the fuel on to the grates over the dead plate. These grates consist of horizontal flat-surfaced bars running from side to side of the furnace, carried on inclined side bearers extending from the throat of the hopper to the rear and bottom of the ash pit. The grates, therefore, in their normal condition form a series of steps, on to the top step of which coal is fed from the dead plate. These steps at the inclination given would, however, prevent the free descent of the coal. But each bar rests in a concave seat in the bearer, and is capable of a rocking motion through an adjustable angle. All the grate bars are coupled together by a rocker bar, the notches of which engage with a lug on the lower rib of each grate bar, pin connections being made with two of the grate bars only, for the purpose of holding the rocker bar in posi-

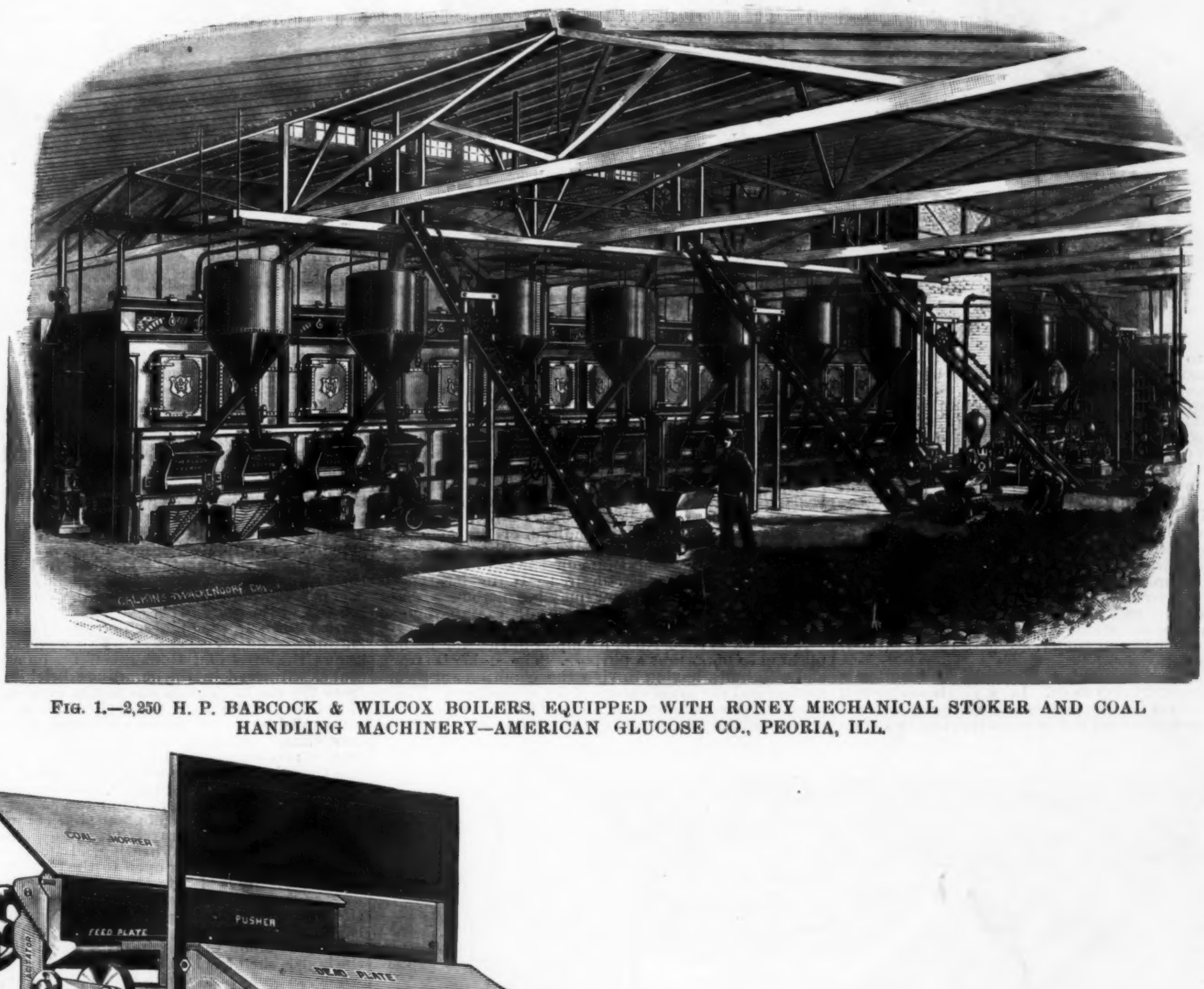


FIG. 1.—2,250 H. P. BABCOCK & WILCOX BOILERS, EQUIPPED WITH RONEY MECHANICAL STOKER AND COAL HANDLING MACHINERY—AMERICAN GLUCOSE CO., PEORIA, ILL.

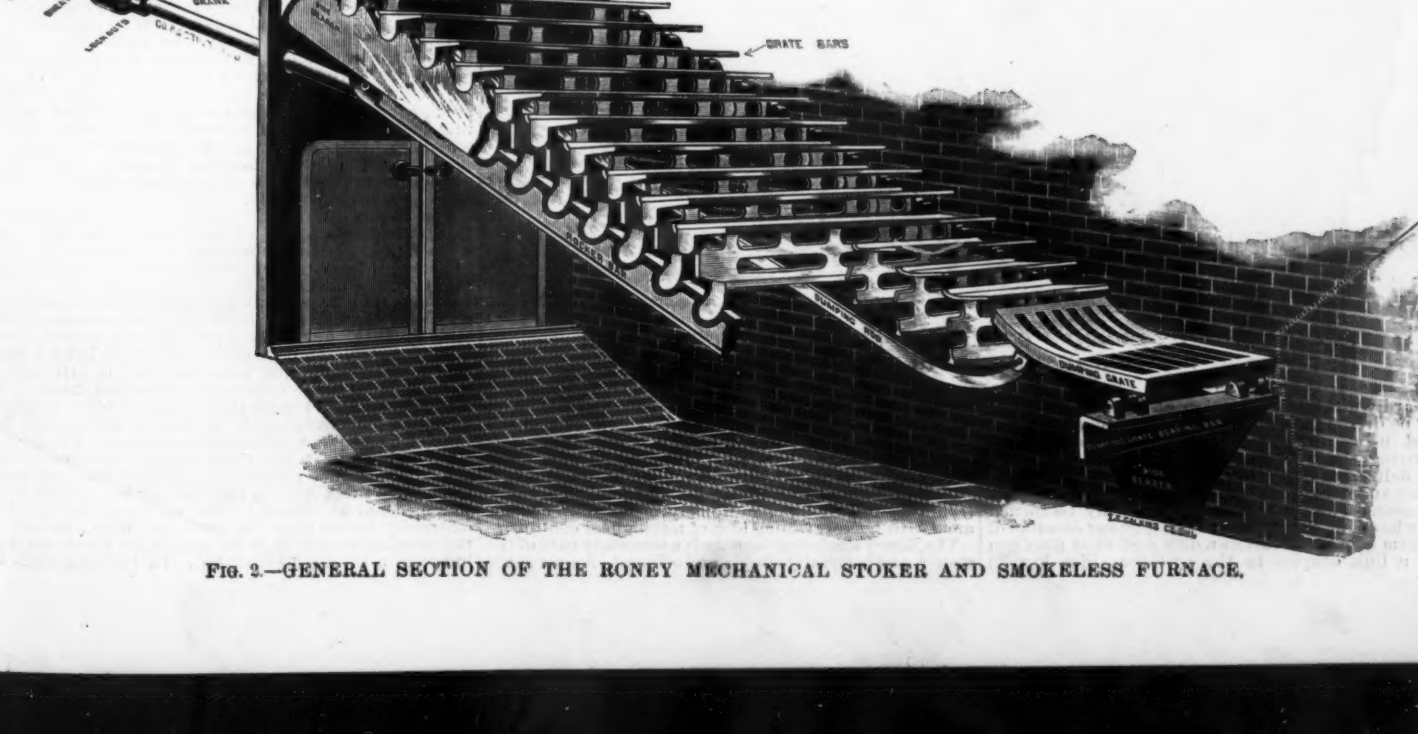


FIG. 2.—GENERAL SECTION OF THE RONEY MECHANICAL STOKER AND SMOKELESS FURNACE.

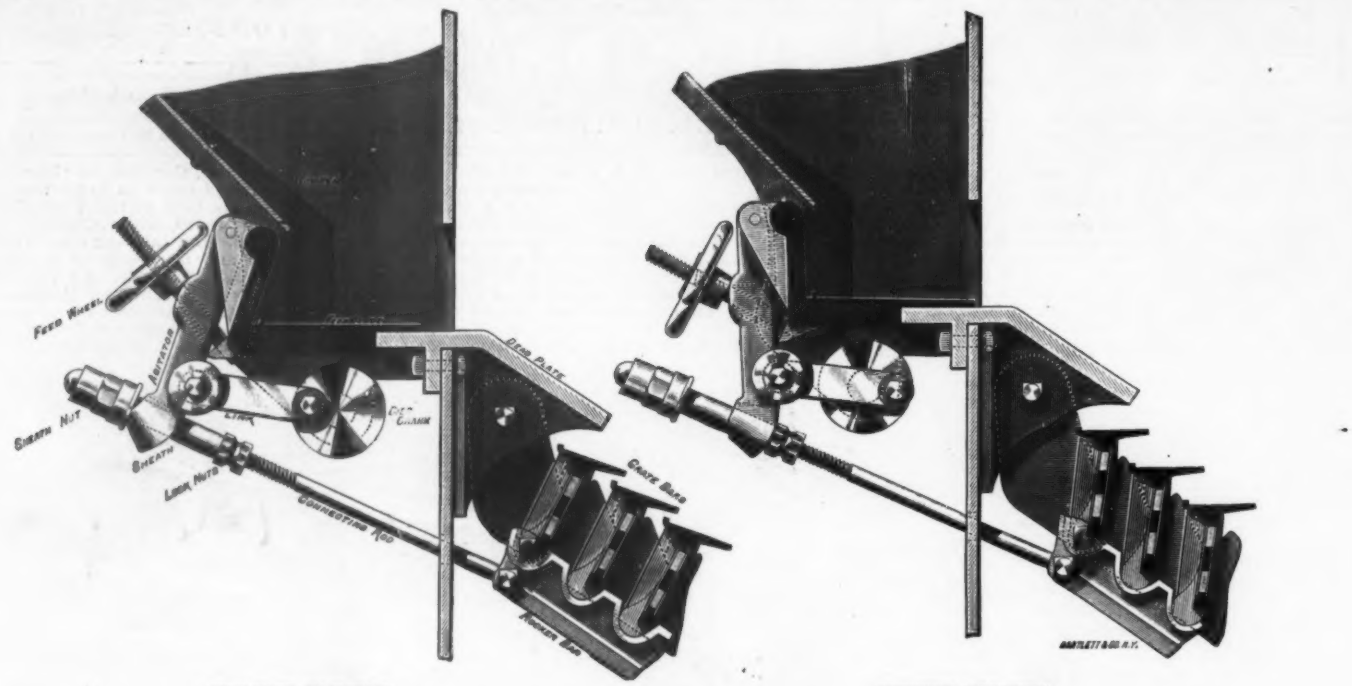
tion. A variable back and forth motion being given to the rocker bar, through a connecting rod, by a device to be hereafter described, the grate bars necessarily rock in unison, now forming a series of steps, and now approximating to an inclined plane, with the grates partly overlapping like the shingles on a roof. (See Fig. 3.) Assuming the grates to be covered by a bed of coal, and fresh fuel being fed in at the top, it is obvious that when the grates rock forward, the fire will tend to work down in a body. But, before the coal can move too far, the bars rock back to the stepped position, checking the downward motion, breaking up the cake thoroughly over the whole surface and admitting a free volume of air through the fire. The rocking motion is slow, being from seven to ten strokes per minute, according to the grade of the coal. This alternate starting and checking motion, being continuous, keeps the fire constantly stirred and broken up from underneath, and finally lands the cinder and ash on the dumping grate below. By releasing the dumping rod, the dumping grate tilts forward (see Fig. 4), throwing the cinder into the ash pit, after which it is again closed ready for further operation. The dumping grate is made in two parts, so that each half can be dumped separately. The operation of the stoker, therefore, consists of a slow but continuous feed, a constant stirring of the fire, and an automatic rejection of the cinder, all performed without opening the fire doors.

The actuating mechanism is simple. All motion is taken from one driving shaft. In a single stoker this shaft may either be driven through a worm gear from a small engine attached to the boiler front and consuming a hardly measurable fraction of a horse power, or it may be driven by a link belt from any convenient point of the nearest shaft. In large batteries of boilers, the driving shaft is extended across all the boiler fronts, delivering power to each stoker, and with the elevators and conveyors is driven by a small independent engine. The largest stoker can easily be turned over by hand, indicating the nominal power consumed. The worm gear shaft carries a disk and wrist pin from which a link couples to the agitator. (See Fig. 3.) Through the eye of the agitator passes a stud screwed into the pusher, on which stud is a feed wheel by which the stroke of the pusher, and consequently the amount of feed, is regulated. The agitator having a fixed stroke, it is apparent that if the feed wheel is run down against it in the position shown in the engraving, the pusher will be given its full traverse and the greatest feed. If run back to clear the travel of the agitator, the pusher will, of course, have no motion, and the feed will stop. Between these extremes any desired rate of feed can be given.

In like manner the rock of the grate bars can be adjusted between any limiting angles, and over a range of motion from no movement to full throw, by means of the sheath nut and jam nuts on the connecting rod. By these two simple adjustments, within the comprehension of the ordinary helper, the whole action of the stoker is controlled and the fires forced, checked or banked at will. There are poker doors in the front on each side of the hopper, through which the whole grate can be seen, and the condition of the cinder on the dumping grate determined. A grate controlled by a couple of hand wheels shuts off the hopper from the furnace altogether when desired. If the location is convenient, a cleaning door may be introduced into the side of the furnace, to facilitate examination of the boiler.

It is hard to conceive of a simpler device for accomplishing so important a purpose. The stoker is strong and well built, having in view the conditions of its operation and the usual nature of its attendance. There are few pin connections or finished parts. The strains are exceedingly light, and the motion is so slow as to be hardly perceptible to the casual observer. Any single bar can be picked out and replaced even easier than in the ordinary flat grate, and in case it is necessary, the lower two bars, where the greatest wear takes place, can be replaced without cooling down the furnace—a source of loss in time and fuel. The boiler fronts are plainly but handsomely modeled, in accordance with the prevailing idea of mechanical contour.

The Roney smokeless furnace is a necessary part of the stoker, and is equally simple and efficient. An air space is left between the fire brick lining and the red brick wall of the furnace. Air is admitted to this space through openings in the stoker front, and by means of brick courses is made to traverse the whole wall, becoming highly heated, and discharging finally into a hollow fire brick chamber immediately over the throat of the hopper, whence it issues through small perforations to mingle with the raw gas from the fresh fuel. A coking arch of fire brick is sprung across the front of the furnace, covering about one-third of the grate and slanting downward at a somewhat less angle. This arch forms a reverberatory furnace whose action is to thoroughly coke the fresh fuel and release its gases before ignition. In fact, that portion of the furnace under the arch may be likened to a gas producer, from the throat of which issues a huge volume of heated gas already partially mingled with the heated air from the side flues, to be quickly burned in the large combustion chamber by contact with the incandescent body of coke on the lower portion of the grates. This action is similar to an Argand burner, which is the standard of complete combustion.



INCLINED POSITION. STEPPED POSITION.

FIG. 3.—DETAILS OF FEED AND GRATE MOVEMENT.

FIG. 4.—DETAILS OF DUMPING GRATE—THE SHADED OUTLINE SHOWS POSITION OF GRATE WHEN DROPPED.

Not the least important element in the smokeless combustion of this furnace is the steady supply of the coal in small but continuous quantity on to the coldest portion of the grate, where, after coking, it is steadily carried down to the highest portion of the fire at the bottom and finally consumed. Every practical fireman knows the effect of a thick green fire on a hot bed of coal as witnessed by the immediate belching of smoke from the stack. This is due to the sudden liberation of volumes of gas from the body of the fresh coal, accompanied by a simultaneous lowering of the temperature, caused partly by the fresh coal itself and partly by the necessary opening of the doors in firing. To this there is no alternative in hand firing, as frequent hand firing in small quantities means frequent opening of the fire doors, which in itself is a smoke-producing condition, besides being of great physical injury to the boiler from unequal contraction and expansion caused by alternate cooling and heating. In mechanical stoking the furnace is never open to the outside air, hence its temperature is always high and *always uniform*—a most important consideration often overlooked. The effect of this on the life and maintenance of the boiler is evident. We prefer in every case, when room will admit, to extend the combustion chamber in front of the boiler shell from three to four feet, the effect of which, in connection with the coking arch, is to protect the gases issuing from the fresh fuel from contact with the boiler, thereby cooling them, and to compel them to traverse the body of ignited fuel, and become entirely consumed in the large combustion chamber.

The Roney mechanical stoker rests its claims largely on the ground of economy. In connection with a large battery of boilers its economy will partially appear in the saving of labor; not only the labor of firing, but by means of elevators and conveyers, which are possible with this construction, the labor of handling the coal and ashes as well. With every boiler, whether single or in battery, the economy will also appear in the efficient burning of slack, culm, yard screenings, cotton seed hulls, rice hulls, chaff, bagasse, and cheap fuels generally.

The money saved in the cost of the lower grades of fuel burned depends of course upon the locality. As a basis, manufacturers may count upon a good quality of screened lump coal of fairly uniform size as necessary to economical hand firing. Since coal slack is seldom less than 30 per cent. and often more than 50 per cent. cheaper than screened lump or run-of-mine of the same quality, many attempts have of course been made to substitute it in connection with hand firing. It is found in practice, however, that in attempting to burn slack upon a flat grate, it cakes into a close mass, shutting off the air supply and yielding volumes of smoke, but little heat. It can therefore only be burned by frequent slicing and cleaning. The cost of labor and the heat lost from constant opening of the fire doors for this purpose is generally found to more than offset the saving in the cost per ton of the fuel. The mechanical stoker, on the contrary, burns slack materially better than the screened lump; in fact, if run-of-mine is used, it is preferable to break up the lumps to a considerable extent. In burning slack in

the stoker, the body of the fire is more even than with lump coals, while the caking is constantly broken up by the rocking motion of the grates, as explained.

It is true that skilled hand firing, such as is employed in expert evaporation tests, will *for a short run* equal mechanical stoking in efficiency; but such hand firing as is commercially available fails far short of mechanical stoking in efficiency, and, day in and day out, for a given grade of fuel the mechanical stoker will get much the best results out of a pound of coal. That is to say, hand firing depends upon a man, and is variable; mechanical firing depends upon a machine, and is uniformly good.

One of the most valuable features of the mechanical stoker in connection with large batteries of boilers is the fact that it makes possible a complete but simple system for the mechanical handling of the coal and ashes. In general terms the coal car is discharged into a hopper feeding to a pair of toothed rolls which crack the large lumps of coal down to a smaller size. If slack is used, of course these rolls are omitted. The coal, after passing the crusher, is elevated to the top of the fire room and taken by conveyers to large storage bins of any desired capacity. From these bins chutes lead to the hoppers of the several stokers. The chutes are arranged to swing altogether out of the way when the boiler tubes are to be cleaned. The ashes are discharged by gravity from the ash pit into other chutes or conveyers, which deposit them finally in the car, bin, or dump heap, as circumstances render most convenient. This system does away with handling of every kind, as the fuel is not touched from the moment the car bottom is dropped until the ashes are finally discharged on the dump. Motive power for the entire conveying system, together with power for the stokers, is taken from a small independent engine in charge of the fireman.

The Roney mechanical stoker finds some interesting applications outside of boiler service. One of the most important of these is illustrated in Fig. 7. It represents a combined reheating furnace designed by us for the Chicago Tyre and Spring Company, at Melrose, Illinois.

A pair of stokers forming one furnace is placed at the head of an ordinary reverberatory furnace for the reheating of steel blooms, the waste heat from which discharges underneath a Hazleton boiler of 400 h. p. Another large stoker is set on the opposite side of the boiler in order to supplement the first pair when the steel furnace is cooled down for charging. This single furnace took the place of a plant of two furnaces, one fired by the best grade of Pittsburg coal and the other fired by gas.

DATA OF COMBUSTION.

For the benefit of those who are interested in the facts underlying perfect combustion, we cannot do better than to extract the concise statements contained in a paper prepared in 1886 by Mr. Edward Bennis, a leading English authority on mechanical stoking. He says:

"A ton of bituminous coal requires for perfect combustion about 336,000 cubic feet of air, or 150 cubic feet per pound of fuel. If the air supply is too great, loss results from the increased weight of heated gases that are sent up the chimney at from 250 deg. to 400 deg., as well as from the cooling effect in the flues.

"But a much more serious loss results from an insufficient supply of air, to understand the nature of which we must study the process of combustion, and what takes place in our furnaces.

"When a charge of fuel is thrown on the furnace by hand, the heat of the fire vaporizes the more volatile gases, which are identical with those so well known in connection with explosions in coal mines, etc., *i. e.* —carbureted hydrogen and bicarbureted hydrogen. These gases are driven off from the fresh coal by the heat with great rapidity, in exactly the same manner as in the retort of a gas works. From the eighty pounds of fuel usually fed to each fire, about forty-four pounds of these gases are generated in say six minutes after the charge, and it must be borne in mind that this is *in addition* to the work being done for the other ten minutes between firing up.

"Of this forty-four pounds, eight pounds consists of hydrogen, requiring for its combustion eight times its weight of oxygen, which is contained in 4,000 cubic

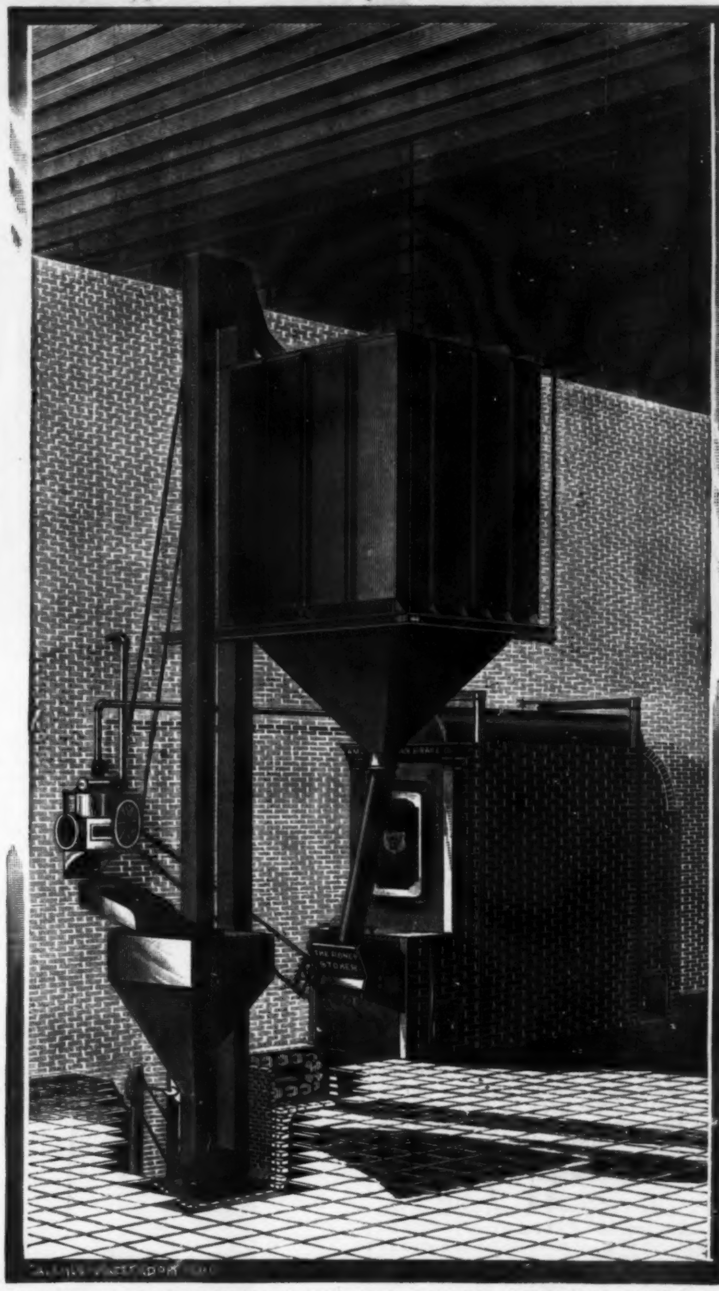


FIG. 6.—SINGLE 125 H. P. BABCOCK & WILCOX BOILER, EQUIPPED WITH THE RONEY MECHANICAL STOKER; ALSO, COAL AND ASH HANDLING MACHINERY—AMERICAN BRAKE CO., ST. LOUIS, MO.

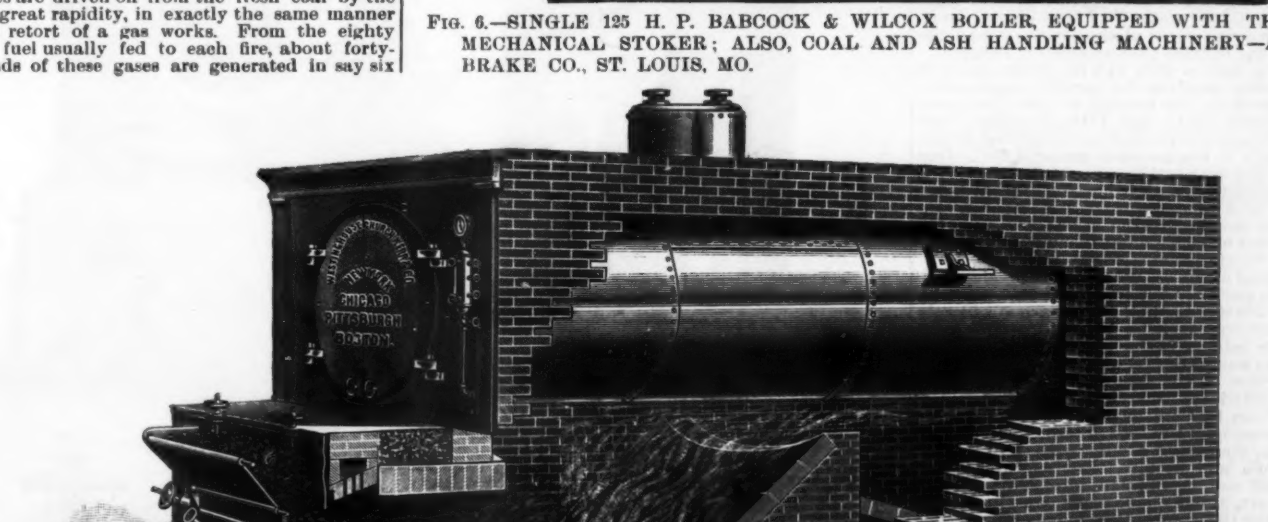


FIG. 5.—GENERAL PERSPECTIVE OF THE RONEY MECHANICAL STOKER AND SMOKELESS FURNACE, AS APPLIED TO A HORIZONTAL RETURN TUBULAR BOILER.

FIG. 7.—60 TON REHEATING FURNACE AND 400 H. P. HAZLETON TRIPOD BOILER, EQUIPPED WITH THE RONEY MECHANICAL STOKER—CHICAGO TYRE AND SPRING WORKS, MELROSE, ILL.

feet of air. Moreover, hydrogen having a more intense combining power than carbon, will take its supply of oxygen first whatever happens. The thirty-six pounds of carbon that have been driven off from the coal in combination with the hydrogen require for their combustion another 4,000 cubic feet of air, and if it cannot get this, some portion of it *must* pass up the chimney as smoke, as it cannot exist by itself as an invisible gas. This is the sole cause of the smoke that pours out of the chimney after each charge of fuel.

"In many furnaces provision is made to admit air after each charge, at the door or bridge, and smoke is largely or wholly prevented thereby, but the resulting loss of both economy and efficiency has created in some minds the impression that the production of smoke is a necessary result of the best work. The effect of an inrush of cold air over the flame is to lower the temperature of the gases below the point at which combustion takes place, viz., 1,000 deg., when any unburned gases will pass into the flues up the chimney, *invisible* but lost, exactly as if, should one gas tap be turned on unlighted, out of five used to light a room, twenty per cent. of the light would be lost. Further, any carbonic oxide in the furnace is arrested in the process of burning, and prevented from doing its share of the work, the importance of which will be presently apparent.

"Air consists of a simple mixture of two gases in the proportion of 77 lb. nitrogen to 23 lb. oxygen—100 lb. air. The nitrogen is entirely inert as regards combustion, and serves only to dilute the resultant heat, so that the weight of products is very much greater than if pure oxygen could be used. The total heat generated is spread over the whole of the products, and the temperature of the furnace proportionately reduced.

"One pound of carbon with 11·6 lb. of air, which is the exact quantity required for perfect combustion, will produce a heat in the furnace of 4,919°, the product being carbonic acid. But 1 lb. of carbon, with half its weight of air, will produce an *invisible gas*, carbonic oxide, with a temperature under 1,510°. One pound of hydrogen with 34·8 lb. air, which contains the oxygen necessary for its combustion, the product being steam, results in a temperature of 4,965°, but in consequence of the greater weight of products, etc., the evaporative power of each pound of hydrogen is four times that of 1 lb. of carbon.

"If then instead of the 336,000 cubic feet of air necessary to consume perfectly one ton of bituminous coal, we supply only 200,000, one-half of our carbon will only be burned to carbonic oxide, and instead of the average temperature being 4,900° it will only be 3,500°, although the same weight of fuel will be consumed. The evaporative power of the fuel being taken at 14 lb., and 3 lb. deducted for this cause, the efficiency is only 11 lb. From this we have to deduct the heat lost in the chimney, by radiation, ash, absorbed by brick work, etc., etc., leaving only from 7 to 8 lb. of evaporation from and at 212°. But as water is supplied at 60° to 80° and evaporated into steam at 70 lb. to 100 lb. pressure, about one-seventh must again be deducted, leaving the evaporation in general practice at 6 to 7 lb., which is the usual experience.

"If we try to remedy the loss by opening the door, and so preventing smoke, the amount of gas passing away entirely unconsumed has been found to be a considerable percentage, and the loss greater—not less. There seems to be no possible remedy by hand firing, as the scattering of so large a weight of fuel on the furnace at once results in such a sudden outburst of gas that it is impossible to supply the requisite air at a temperature of 1,000°, and in a right way.

"In hand firing, the fire being charged every quarter of an hour with fuel, heat is absorbed in the process of converting the solid fuel into gas; the temperature falls about 1,500° in the furnaces, while as a requisite supply of air cannot be had at a temperature of 1,000°, or in small streams, the gas is only partly utilized until after 2 or 3 minutes the flame reaches 20 or 30 feet, when the temperature rises to its highest point, then gradually falls till the fire is raked or firing repeated. These operations, involving variations of temperature exceeding 1,500°, with consequent expansion and contraction of boiler plates, prevent the boiler 'from living out half its days.' A good boiler to work at 90 lb., properly set and used in a rational way, ought to work at 90 lb. for 15 to 20 years as a minimum.

"The formation of clinker adhering to the bars, and consequent reduction of draught, and of work done per hour, is a great drawback in hand firing."

IMPROVED PETROLEUM MOTOR.

THE small petroleum motor illustrated by the accompanying engravings is designed for the many applications which modern requirements offer for a small easily started motor. The size illustrated is about one-sixth horse power; sufficient for most of those requirements which, although below the power of one man, will perform continuously that which is too fatiguing for hand or foot work. It has been made under the patent of Mr. Edward Butler, in the works of Mr. F. B. Shuttleworth, at Erith, where a much larger size of engine is being made for launch work, and a different form for driving a tricycle. The little engine is very readily and easily started, and the electric ignition seems to introduce no difficulty.

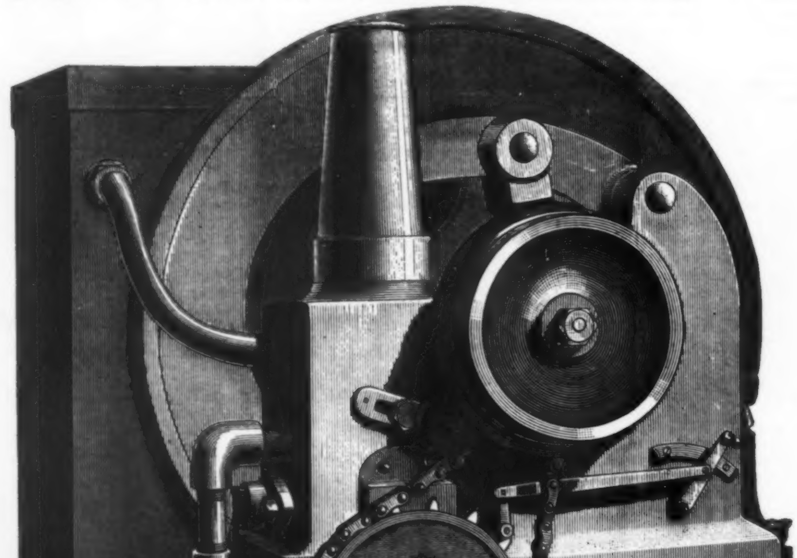
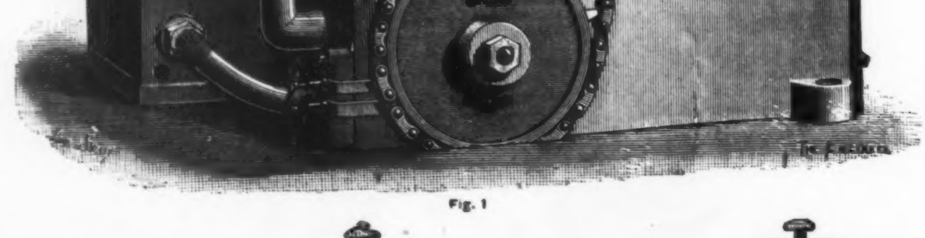
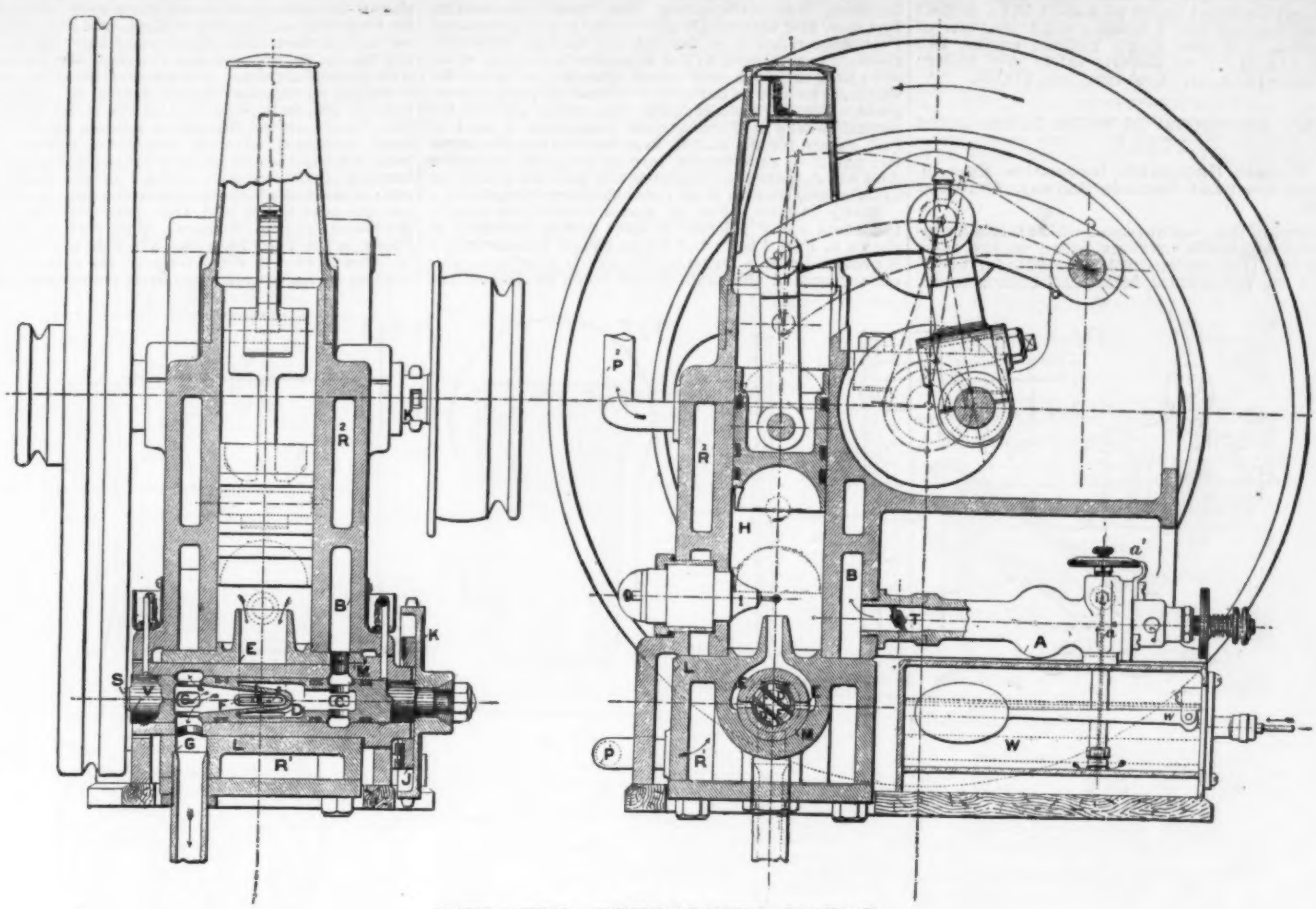


Fig. 1



Figs. 4

IMPROVED PETROLEUM MOTOR.



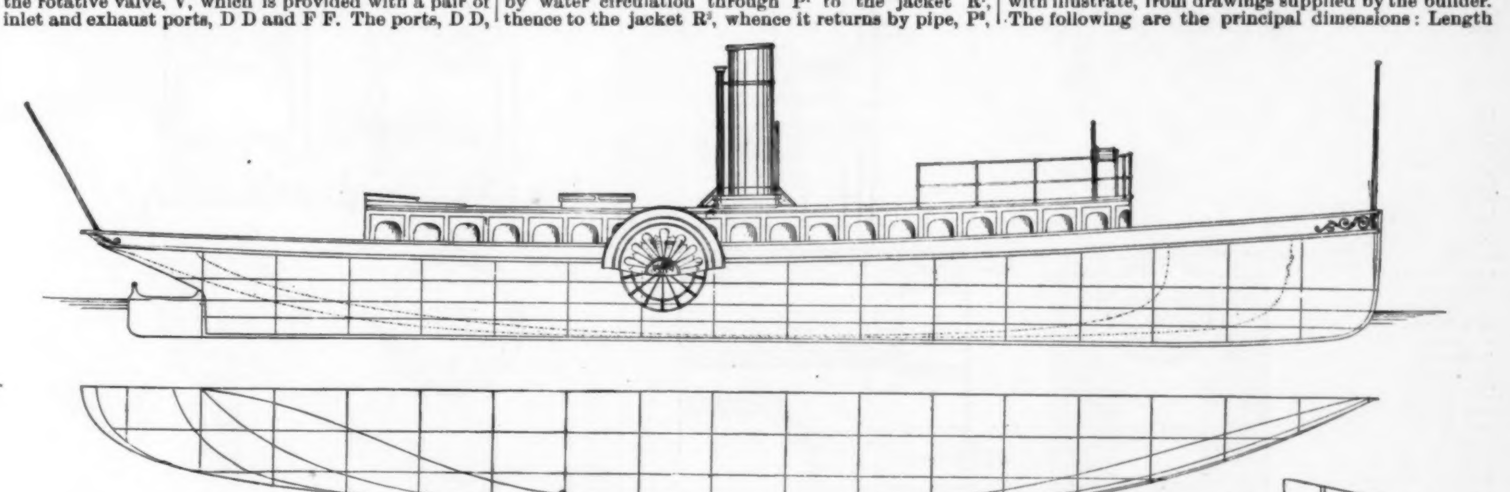
IMPROVED PETROLEUM MOTOR.

In our engravings, Fig. 1 is a perspective view, showing the engine in front of the small tank containing water for the jacket. In the front are seen the pitch chain wheel, which is fixed to the end of the nearly cylindrical valve by means of which the charge of petroleum vapor and air is admitted. The small handle, which controls a throttle valve for starting and stopping, is also seen in this view. In Fig. 3, W is a petroleum well—shown to a larger scale in Fig. 4—having the float valve, *w*, connected by a $\frac{1}{8}$ in. pipe to a half gallon supply can, which holds oil for a day's run. Over the well is an atomizer, A—shown in section in Fig. 4—into which oil is induced to flow up the pipe a^2 by the flow of air drawn through a nozzle arrangement by the motor piston. The index valve, a^1, regulates the oil feed. The mixture of air and oil spray formed in this atomizer is volatilized in the chamber, B—see Figs. 2 and 3; it is then distributed to the cylinder by the rotative valve, V, which is provided with a pair of inlet and exhaust ports, D D and F F. The ports, D D, communicate by ports and passage, C, to the chamber, B, and the exhaust ports, F F, by G, with the exhaust pipe. Communication of these ports with the cylinder is by the ports, E E, in the seating, M, and cover, L. The piston works in the four-stroke compression cycle, and the valve rotates once for every two complete revolutions; it is kept up to its seat by a spring at S. The speed is controlled by a throttle valve, T, connected to the hand lever, seen in the perspective view. The ignition is effected by the passage of an electric current across terminals carried by the insulator, I, which is induced in a coil placed in connection with a small special bichromate battery at the right periods, by means of contact plates on the commutator, J, at the back of the valve chain wheel, K. When not using the motor for more than an hour at a time, an ordinary bell battery is said to supply sufficient current.

Overheating of the valve and cylinder is prevented by water circulation through P^1 to the jacket R^1, thence to the jacket R^2, whence it returns by pipe, P^2, to the tank—about five gallons. The cylinder and body are in one casting. The piston being connected by two short rods and arm to the crank—$1\frac{1}{4}$ in. radius—allows a somewhat quicker outstroke than return, besides rendering the motor very compact. The size of the cylinder is 2 in. by $3\frac{1}{4}$ in. stroke, and the revolutions are variable from 250 to as much as 800 per minute. The total height of the motor is $16\frac{1}{2}$ in.; width of base, 7 in. by 12 in. over the lugs; and the weight, without water tank, 110 lb.—*The Engineer*.

THE LIGHT DRAUGHT PLEASURE BOAT CONNETQUOT.

MR. HENRY PIEPGRAS, ship and yacht builder, City Island, N. Y., has lately built a small side wheel steamboat for Mr. W. K. Vanderbilt, which we herewith illustrate, from drawings supplied by the builder. The following are the principal dimensions: Length



THE LIGHT DRAUGHT PLEASURE BOAT CONNETQUOT—HENRY PIEPGRAS, ENGINEER AND BUILDER.

over all, 78 feet; length on load water line, 70 feet; beam, 14 feet 6 inches; depth of hold, 4 feet 6 inches; draught of water, 2 feet 3 inches; cubic contents of displacement, 32½ tons; single inclined engine, two cylinders, 10 × 20 inches; Roberts safety tube boiler; speed 14 miles per hour. Cost complete, $16,000.

WORKING LOCOMOTIVES WITH PETROLEUM FUEL.*

By Mr. THOMAS URQUHART, Locomotive Superintendent, Grazi and Tsaritsin Railway, Southeast Russia.

THE object of the present paper, which forms a supplement to the author's previous paper on the same subject in 1884 (Proceedings 1884, page 272; for previous paper see SCIENTIFIC AMERICAN SUPPLEMENT, No. 455), is to bring before the Institution the more recent results of his experience in the use of petroleum refuse as fuel on an unprecedented scale upon the Grazi and Tsaritsin Railway, Southeast Russia. The very general and increasing interest arising out of the former paper and its discussion bears testimony to the growing importance of the subject in all countries; and any authentic data from the results of practical experience extending over a number of years are sure therefore to be more or less acceptable. Since the publication of the original paper in 1884, nothing new in principle has been discovered; the same appliances still continue in use, having undergone only the very slight modifications suggested by experience and by constant observation, with a view to simplicity and cheapness.

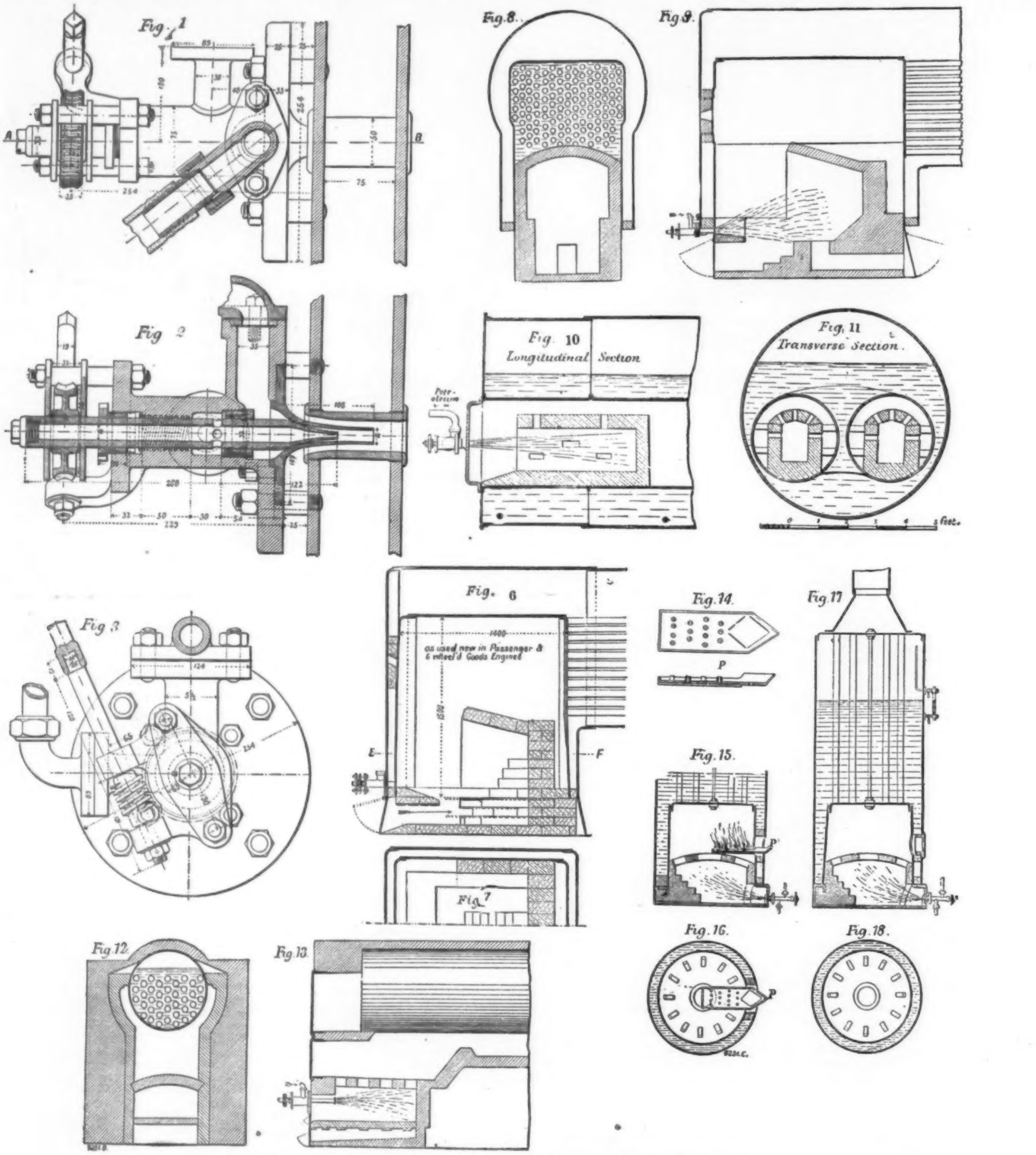
Since November 1, 1884, the whole of the 143 locomotives under the author's superintendence have been fired with petroleum refuse, besides fifty stationary boilers, both horizontal and vertical, two scrap-welding furnaces, four tire-heating fires, two brass-melting furnaces, and three plate and spring heating furnaces. Petroleum refuse is in fact the fuel used for all steam-generating purposes, to the complete exclusion of all solid fuel, except a very small quantity of wood for starting the fires in horizontal boilers of pumping engines. For all metallurgical operations also at the central works at Borisoglebsk petroleum is used as fuel, except for the smiths' fires and the foundry cupolas; and from experiments now in progress the author does not despair of overcoming the present difficulties in its application to these two remaining exceptions.

Spray Injector.—For all goods locomotives exactly the same spray injector is used now as formerly, as shown in Figs. 1 to 3; but for passenger locomotives it is provided with a longer nozzle, which is indispensable on account of the trailing axle being so close to the back of the firebox, and thus coming in the way of the injector. The main dimensions of this spray injector are exactly the same as in Figs. 1 to 3, the only difference being in the length of the nozzle. The divider or vertical grid at one time used inside the firebox, close in front of the orifice of the spray injector, for the purpose of still more thoroughly breaking up the spray jet, is now discarded in favor of bringing the brickwork closer up to the orifice, so that the spray may break itself against a rugged brick wall.

Regenerative or Accumulative Combustion Chamber.—Many experiments were made with a variety of forms of brickwork inside the furnace or firebox. For locomotives the author's mature experience has reduced these to the two constructions shown in Figs. 6 and 7 for six-wheeled goods and passenger engines, and in Figs 8 and 9 for heavy eight-wheeled goods engines. In the latter case the spray injector is placed under the firebox ring, and delivers the jet through the rear end of the ashpan, these engines having deep ashpans which admit of this arrangement. In Figs. 10 to 18 are shown the arrangements of brickwork severally used for Galloway and marine boilers, and also for horizontal boilers fired underneath, and for vertical boilers. For the latter, even when quite cold, the fire is started with petroleum alone, without any wood, by means of a simple contrivance which serves its purpose very well; as shown in Figs. 15 and 16, a cast iron pan, P, Fig. 14, is inserted through a firedoor above the brick vault, and is filled with petroleum refuse poured in from the outside and ignited, air being admitted to the burning liquid through nipples in the bottom of the pan; as soon as steam is raised, the pan is withdrawn and the door closed, and the spray injector started at the bottom of the furnace. The vertical boiler here shown is 7 ft. 9 in. high and 3 ft. 6 in. in diameter, with 50 tubes of 2 in. in diameter and 155 square feet total heating surface; working at 55 lb. per square inch above the atmosphere, it drives an engine of 8 horse power nominal, and burns 27 lb. of petroleum refuse per hour. In Figs. 19 and 20 is represented a combination of furnace for petroleum and wood firing, as actually used in the wagon-repairing shops at Borisoglebsk, where quantities of chips, shavings, old timbers, and sawdust are to be had for fuel; but should there be any scarcity of wood fuel, the petroleum-burning appliances fitted to the furnace as here shown can be started at a moment's notice. It is still the author's opinion, as it has been all along, that the form, mass, and dimensions of the brickwork are certainly the most important elements in this plan of utilizing liquid fuel, if not indeed in any plan.

Several tables of details are given by the author, of which the general nature and results are described as follows:

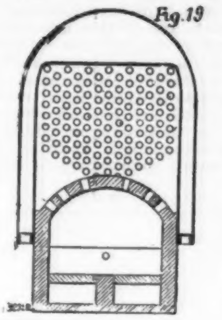
Cost of Altering Locomotives for Petroleum Firing.—In Table I. is shown the cost of altering a locomotive of 5 ft. gauge, according to the two different plans fol-

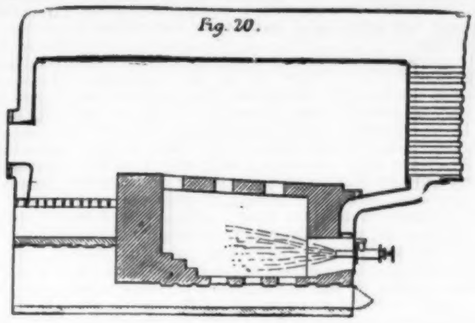


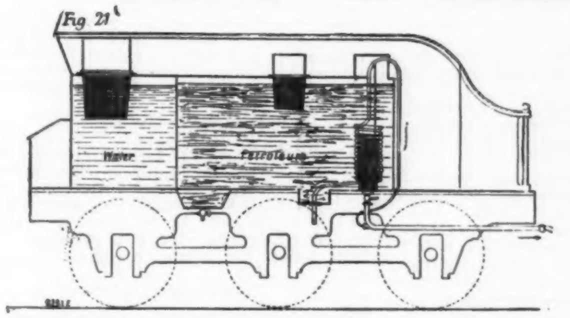
THE USE OF PETROLEUM FUEL IN LOCOMOTIVES.

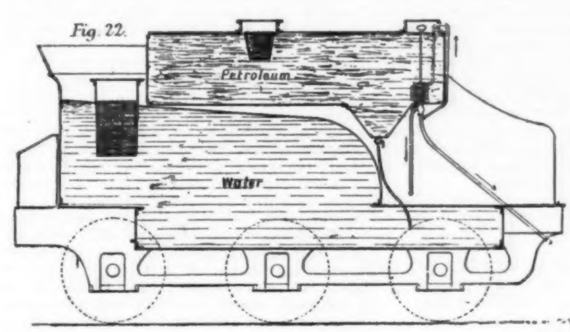
* Paper read before the Inst. of Mechanical Engineers.—*Engineering.*

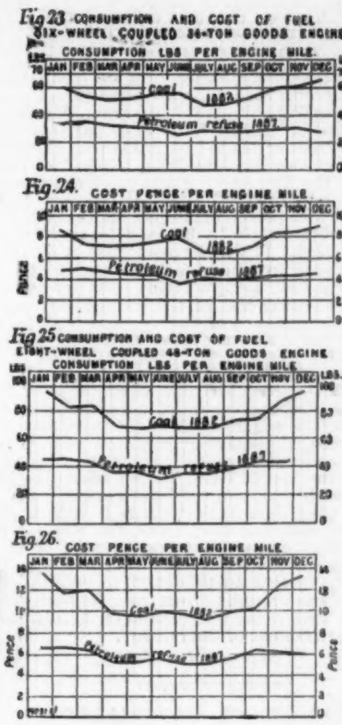
lowed by the author on the Grazi and Tsaritsin Railway, the difference relating more to the tender than to the engine. The figures given of the costs include all details of the alterations, and are at local Russian prices; and as the rate of exchange at the time of the former paper in 1884 made one paper ruble equal to 2s., this value is adhered to throughout the present paper also. In the six-wheeled engines the original coal space in the tender was found to be of sufficient capacity for containing the necessary supply of liquid fuel, and required, therefore, simply to be plated over, as shown in Fig. 21; it is plated top and bottom, and a bulkhead is added across the front; the tank so formed

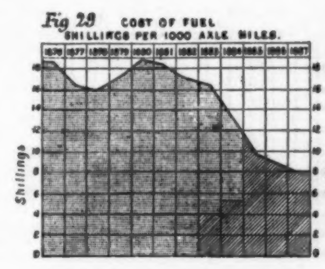


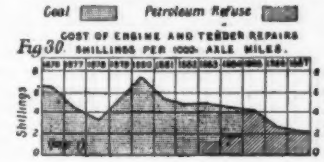


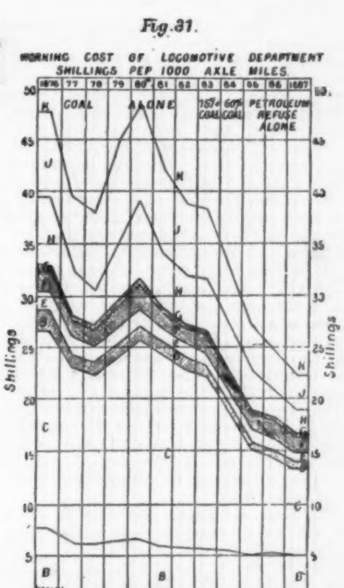


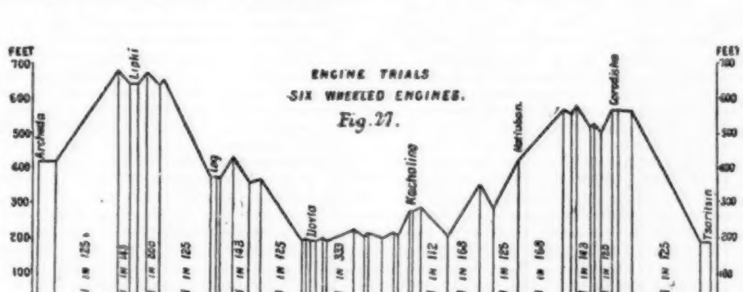


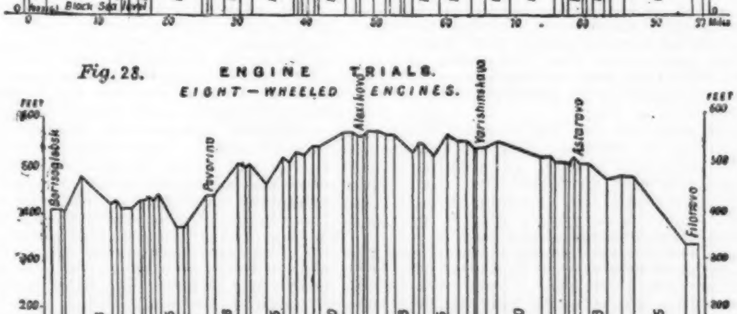












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contains 123·9 cubic feet, or 772·5 gallons. In the eight-wheeled engines the capacity of the coal space was inadequate; and here, therefore, a separate tank had to be resorted to, which is placed above the tender tanks, as shown in Fig. 22, and has a capacity of 227·3 cubic feet, or 1,417 gallons. This arrangement is, of course, the more expensive of the two.

Results of Working.—In Table II. and the corresponding diagrams, Figs. 23 and 24, are clearly shown both tabularly and graphically for six-wheel coupled 36 ton goods locomotives the comparative consumption and cost of fuel per engine mile over a whole year when burning coal only and petroleum refuse only. A corresponding comparison for eight-wheel coupled 48 ton goods locomotives is shown in Table III. and diagrams, Figs. 25 and 26. In 1882 coal only was used, of which 63 per cent. was anthracite and 37 per cent. bituminous; whereas in 1887 all the fuel used was petroleum refuse. The tables and diagrams show for both fuels alike the whole service of each class of locomotive, including train haulage, shunting, running without train, and standing in reserve under steam; discrepancies, therefore, cannot occur. Moreover, these results include the effects of good, bad, and indifferent firing; they consequently show broad averages, which the author considers can be thoroughly relied upon.

Besides the separate monthly statements, a summary of the year's working is given at the bottom of each table, which may be taken as very conclusive. In the six-wheeled engines the average cost of fuel per engine mile is seen, from Table II., to have been reduced from 7·64d. for coal in 1882 down to 4·43d. for petroleum refuse in 1887, being a reduction of 42 per cent.; while from Table III. it is seen that in the eight-wheeled engines the reduction was from 11·02d. for coal in 1882 down to 5·84d. for petroleum refuse in 1887, which is a saving of 47 per cent. The yearly cost, as summarized for each class of engine, must, of course, vary with the fluctuations in the cost of the petroleum refuse per ton. In 1885 the cost per ton in the barges at Tsaritsin on the Volga was 17s. 5d., whereas at the end of 1887 it had fallen to 13s. 7d. The cost per engine mile, given in Tables II. and III., includes cost of transport, storage, superintendence, and depreciation of tanks, pumps, pipes, etc.

From Table II. it will be seen that the equivalent of 100 tons of coal in 1882 in the six-wheeled engines was 55 tons of petroleum refuse in 1887, being a reduction of 45 per cent. in weight of fuel; while from Table III. the saving of weight in the eight-wheeled engines came up to 49 per cent. in 1887, that is 51 tons of petroleum refuse were equivalent to 100 tons of coal. These broad comparisons, extending over a whole year's running with each fuel, include of course all the ordinary fluctuations both in working and in condition of engines. With a locomotive in first class order and in the hands of a skillful driver, the author has no hesitation in saying that 50 tons of petroleum refuse are equal to 100 tons of first class coal, while in special trials this ratio has even been exceeded. But it would not be safe to draw from special trials conclusions regarding ordinary working; and therefore the comparison presented by Tables II. and III. is to be preferred as most authentic.

In Table IV. is given the comparative consumption of anthracite and of petroleum refuse per train mile and per ton mile in the six-wheeled and eight-wheeled goods locomotive, as ascertained in special trials made respectively in 1883 and in 1884. The trials of the six-wheeled engines extended over one double journey, with each fuel, on the section of line between Tsaritsin

and Archeda, a distance of 97 miles, of which the profile is shown in Fig. 27, with the gradients marked thereon. The result is seen to be that the equivalent of 100 tons of anthracite was 48 tons of petroleum refuse, being a reduction of 52 per cent. in weight of fuel. The trials of the eight-wheeled engines were made on the 69 miles length of line between Borisoglebsk and Filonoff, of which the profile is shown in Fig. 28 with the gradients marked. The coal-burning engine ran six double journeys and the petroleum engine twenty-four, with the result per ton mile that 45 tons of petroleum refuse was equivalent to 100 tons of anthracite, being a reduction of 55 per cent. in weight of fuel per ton mile. These comparisons were made with the greatest care possible, with engines in first class order, thus showing the highest efficiency possible in locomotive practice; the result must therefore be looked upon as exceptional.

In order to present in another form the comparative cost of working with coal and with petroleum, the cost of fuel is given in Table V., and in diagram, Fig. 29, per 1,000 axle miles of trucks, wagons, or carriages (not locomotives), whether loaded or unloaded, extending over a period of twelve years from 1876 to 1887 inclusive. During the first seven years to 1882 coal alone was the fuel used; in 1883 about 25 per cent. of the work was done with petroleum refuse, and in 1884 about 40 per cent.; while in 1885 to 1887 petroleum refuse was the sole fuel used. It will be seen that from 17s. in 1882, the last year in which coal was used alone, the cost fell to 8s. in 1887, being a saving of 53 per cent.

The entire working cost of the locomotive department for the same period of twelve years from 1876 to 1887 inclusive, per 1,000 axle miles of trucks, wagons, or carriages (not locomotives), whether loaded or unloaded, is given in Table VI. and diagram, Fig. 31. The item of fuel, which in Table V. consisted of that burnt in the locomotives only, here includes also that burnt in the engine sheds and drivers' rooms, as well as expenses of management of the fuel department; it is consequently rather higher than shown in Table V. At the foot of Table VI. are added the total axle miles in each year, and the total working cost. It will be seen that from 39·13 shillings in 1882, the last year in which coal was used alone, the working cost fell to 22·35 shillings in 1887, being a saving of 43 per cent. Consequently, although the total axle miles rose from 97,927,740 in 1882 to 136,420,000 in 1887, the total working cost was brought down from 191,442*l.* in 1882 to 152,278*l.* in 1887, being a reduction of 39,164*l.* in the locomotive department of the railway.

(*To be continued.*)

REFRACTORY MATERIALS.*

By T. EGLESTON, Ph.D.

ALTHOUGH the success of metallurgical operations depends so largely on the possibility of finding proper refractory materials, which enter so prominently into the cost of their operations, it can hardly be said that our knowledge of them is in a very satisfactory condition, or even that we know very much about them, beyond a few facts which have been gathered through their use. Experience, as a general thing, is an excellent master, but the requirements of modern metallurgy increase so quickly that the acquirements of experience become rapidly useless, because the exactions of temperature are so continually increased that the material depended on yesterday is of little value to-day.

The conditions which the refractory materials of today are called to fulfill are very different from those demanded a few years ago, and unless a better and, at the same time, a cheaper material than we now have can be found, there are some industries which must die out altogether, and others which, if they survive at all, can never take the commercial place which their metallurgical value would otherwise command for them. Mr. Holley has shown that the cost of the refractory materials of the Bessemer process is one dollar per ton of ingots; that in this country for the Siemens-Martin process it is five dollars per ton of ingots, while in Wales it is only one dollar; a difference in cost, other things being equal, sufficient to almost prevent competition in times like these.

In the use of a given refractory material it will often be found that the same substance is called upon to fulfill conditions which are not only different, but exactly the reverse the one of the other. At one time it must resist an oxidizing, and immediately after withstand more or less of a reducing action. Now, the action is neutral, followed by the corrosive action of chlorine or sulphuric acid, or again the action is that of basic scoria, and immediately afterward that of metals in fusion. The same substance must resist destructive mechanical action as well as the chemical action of melted oxides, sulphides, and silicates, and at the same time be proof against any amount of heat. We seem to be astonished, and often complain, that a brick which resists the influence of oxide of iron should fail entirely under a gas flame, and that one should slag under the influence of oxide of iron but resist any amount of clear heat, and yet, when the nature of the material is considered, we see that it could not very well be otherwise. In many cases, and in certain portions of a furnace, the brick may be called upon only to support a very high temperature, coming in contact with the flame only, and this is the most trying condition of all our modern requirements, for the material must resist the temperature and remain infusible without decomposition, cracking, or alteration of any kind, and still retain strength sufficient to resist the pressure of the furnace. No materials are required to withstand so many and so varied conditions as crucibles, retorts, and furnace linings, yet the success of most metallurgical operations depends on their resistance under all the varying circumstances.

We must fairly regard the condition of our knowledge of this subject as one of the weakest sides of modern metallurgy. A review of it at this time, when we are called upon to economize in every direction, may not be out of place, for there are few departments in which there is so much scope for economy as here.

REFRACTORY SUBSTANCES.

The substances with which we have to deal as refractory materials are silica, alumina, lime, magnesia; clays, which are silicates of alumina, more or less pure; the hydrated aluminate of iron, known as bauxite; and some silicates of magnesia, as talc, steatite, and the minerals which are allied to them, all of which substances are fusible in the strictest sense of the word, but are generally infusible at commercial temperatures. To these substances two others must be added, as powerful agents to render infusible, under certain conditions, substances which would otherwise be fusible, and these are water and carbon in the shape of coke or graphite.

Some few rocks are used as refractory materials without undergoing change. These rocks are quartzites, granites, some sandstones, conglomerates, serpentines, steatites, and, in certain rare cases, as in Styria, carbonate of lime. Quartzites and sandstones were, for a long time, used almost exclusively for blast furnace hearths. They are very refractory, but very treacherous, as they are not homogeneous. Some aluminous shales are also used, and will generally stand if they do not contain more than from four to six per cent. of iron, the alkalies and the alkaline earths together, but it is not easy to use them. They are not easily cut, must be laid in their quarry bed, and are liable to crack. Other rocks of the soapstone and serpentine varieties, which contain sixty to sixty-five per cent. silica and twenty to twenty-five per cent. magnesia, are infusible, easily cut, and, if they do not crack, can be used; but, in general, natural substances are not homogeneous, are difficult to get in sufficient quantities, and so little to be depended upon that artificial materials are preferred.

Silica is found in nature anhydrous and hydrated. The anhydrous, which is quartz and jasper, cannot be used alone, as it cracks and splinters. If it is to be used, therefore, it must be reduced to powder. The hydrated varieties gelatinize with acids, and are found as powders and soft stones, which pass under different names in different countries. They contain from 30 to 87 per cent. of gelatinizing silica, 2 to 10 per cent. of water, and 0 to 42 per cent. of insoluble silica, with 2 to 10 per cent. of iron, alkalies, and alkaline earths. These impurities are generally in too small quantities to affect its refractory qualities. Some varieties of this rock are so tender that M. Deville has had crucibles made of them in a lathe; but, as the composition is never regular, vessels made of a mixture are always better. Though silica is infusible, it cannot, generally, be used without being ground, and as it has no binding property like alumina, a small portion of binding material must be added to it to make it hold together. For the Dinas brick, which is the best substance to resist heat alone, this binding material is lime. This brick is made of quartzose sandstone, which is first heated in a furnace, and thrown into water to break it up, and is then ground. It is composed of—

Silica	98·31 to 96·73
Alumina	0·72 to 1·39
Ferric oxide	0·18 to 0·48
Lime	0·22 to 0·19
Alkalies	0·14 to 0·20
Water	0·35 to 0·50

BINDING MATERIALS.

The amount of lime required to bind it together is 1½ per cent. The joints between the bricks are filled with the same material. At a temperature of 2,200 deg. C., about 4,000 F., these bricks will last four weeks in the roof of an ordinary furnace, and in that time will be reduced—by abrasion of the flame and dust, and slightly from chipping—from nine to two inches. The bricks conduct the heat so badly that at this temperature, which is a bright white heat on the inside of the furnace, it is only just warm on the outside. Ordinarily, the bricks seem to be fluxed away by the dust, which circulates with the gases. In the Siemens furnace, where there is no dust, they give out from weakness. They cannot be applied to any part of the furnace where there is any wear. The principal cause of their deterioration seems to be the lowering of temperature due to stoppages on Sunday, when the bricks flake, either as the furnace cools or when it is again heated. It was at first supposed that these bricks could only be made from the Dinas stone, but it is now known that they may be made from any pure silicious rock which has been ground and mixed with the proper quantity of lime.

In ganisters, used for the Bessemer converters, the binding material is alumina, chemically combined with silica, in the shape of clay. It is generally used unburned, and it is very important that the mixture should be so made that it will expand a little, but not shrink at all. For this purpose, quartz, as pure as it can be had, is mixed with aluminous clay.

Silica is generally a very cheap material, and preferable to any other substance, if it is used only to resist heat, but cannot be used if any considerable quantity of scorias are to be formed. In such cases, bauxite or other aluminous material will be found to be preferable.

Lime, or lime rocks, cannot generally be used in commercial operations, because the carbonate, the only form in which we have it, becomes caustic under heat, and this, when left to itself, absorbs water and falls to powder. It can be used when an operation is continuous, but in no other case. In Styria the hearths and sides of blast furnaces are sometimes made of it, but they are generally quickly abraded, and make but short campaigns. Lime is infusible; bricks of it are used for the fusion of platinum. It is, however, very easily acted upon by silica, but when this is absent it is one of the most refractory substances known.

Magnesia made from the carbonate by driving off the carbonic acid is very refractory, if pure. It is made into any shape that is required, and is one of the most refractory of substances. It was formerly very difficult to get the carbonate of magnesia, but large quantities of it have been found on the island of Eubea, so that it can now be had for $15 to $25 a ton, instead of $60 to $70, as formerly. It can be calcined at a less cost than ordinary lime, losing half of its weight, so that if calcined before it is transported, the cost may be still further reduced. It contains a little lime, silicates of iron and some serpentine and silica. After calcination, the serpentine and silica separate, as it is easily crushed, but the most of the work can be done by hand picking beforehand. Before moulding, it must be submitted to about the temperature it is to undergo in the furnace, otherwise it would contract. It is then mixed with a certain portion of less calcined material, which is one-sixth for steel fusion and ten to fifteen per cent. water by weight, and pressed in iron moulds. If for any reason—either because there was too much or too little water, or because the material was not properly mixed, or contains silica—the crucible is not strong enough, it has only to be dipped in water which has been saturated with boracic acid, and then heated.

Bauxite is one of the natural substances which has been recently applied as a refractory material. It is a compound of silica, alumina, oxide of iron and water. Like all aluminous substances, it has the advantage of tending to form aluminates, which are less fusible than silicates, and are generally completely infusible at commercial temperatures. It does not have a very constant composition, as silica is sometimes not even present at all, as is shown by Berthier's analysis given below:

	Berthier.	Deville.	School of Mines.
Alumina	52·0	58·1	60·00
Ferric oxide	27·6	3·0	0·80
Silica	....	21·7	23·00
Water	20·4	14·0	15·00
Titanic acid	....	3·2	....
	100·0	100·0	98·80

Almost all the aluminates of iron are fusible. Siemens has taken advantage of this to make bauxite bricks, which have the composition: alumina 50 per cent., sesquioxide of iron 35 per cent., silica 3 to 5 per cent. They last five or six times as long as the best Stourbridge bricks. Nothing has yet been found which resists the corrosive action of basic slags so well.

FIRE BRICK MATERIALS.

The materials of which fire bricks are generally made, however, are fire clays, which are hydrated silicates of alumina, containing from 50 to 65 per cent. of silica, 30 to 75 per cent. of alumina, and 10 to 15 per cent. of water. The relation between the silica and the alumina is exceedingly variable, owing to the fact that a part of the silica, which is not always the same, is combined and a part uncombined. The quantity of water is also variable, as part of it is hygroscopic and can be driven off without injury to the clay. The plasticity generally depends on the water of combination, which, when driven off at a red heat, cannot be made to combine again, so that this property is then entirely lost. It contains, besides, a small quantity of other elements, such as potash, soda, lime, magnesia, and iron, and is generally less refractory the more it contains of them. When it contains from 6 to 10 per cent., it will generally melt. When the clay is silicious, 3 to 4 per cent. of other substances make it fusible. When it is aluminous, 6 to 7 per cent. of oxide of iron does not make it lose its refractory qualities, owing to the very refractory nature of most aluminates. When, therefore, the corrosive effects of basic slags are to be feared, aluminous clays must be used.

Almost all clays contain organic matter; if present alone it makes the clay more refractory, since the presence of even a small amount of carbon tends to increase its resistance to heat, as seen in graphite crucibles. Pure material, composed exclusively of silica and alumina, would be completely infusible. Such material is, however, exceedingly rare. The property of infusibility is always more or less compromised by the presence of foreign substances, which tend to reduce it or take it away altogether. The clay which, according to Brogniard, is the most refractory when deprived of its hygrometric water has the composition: Silica, 57·42; alumina, 42·58.

While the refractory nature of clay is due, to a very great extent, to its chemical composition, it is not due to it alone. There are, probably, no two beds of clay in the world, or even different parts of the same bed, that have exactly the same composition, and yet they may be very nearly of the same quality. The power to resist heat is, undoubtedly, owing to the molecular condition of the particles, a subject which has been but little studied and is but little understood. Many clays which would be rejected from chemical analysis alone are sometimes found in practice to be excellent refractory materials. It has been found that the refractory nature of the clay depends also, to a great extent, on the mechanical arrangement of the particles, for of two materials having exactly the same chemical composition, one being coarse and the other fine, the coarse may be practically infusible, while the fine may be more or less easily fusible. The more porous the same substance is, the more infusible it will be. It may be said in general terms that the value of a given refractory clay will be inversely as its coarseness and as the amount of iron contained. When the amount of iron reaches 5 per cent., the material becomes worthless.* This is true, however, only in general, for Pettigand cites an excellent clay from Spain in which there is 25 per cent. of iron. This is, however, an exception.

In order to be useful, clays should be, or should be made to be, more or less plastic, as this property is necessary to their being moulded into the shapes required. This plasticity is owing, first, to the fineness of the particles, to the presence of alumina, and to the water of combination. It is diminished by the presence of iron, lime and magnesia. The refractory nature of the clays, then, is due to the presence of alumina, or silica in excess, and to the absence of potash, soda, lime, magnesia and iron.

The characteristics of all fine clays may be said to be that they do not effervesce with acids, that they make a paste with water, which is absorbed so rapidly as to make a slight noise. This paste can be drawn out without breaking, and is very plastic. Dry, they are solid, and break into scales when struck. They have a soapy

* This article was written at the suggestion of the Committee on Refractory Materials of the American Institute of Mining Engineers, with a view of calling attention to the anomalies and difficulties of the subject. It was hoped that its discussion would eventually lead to the appointment of a commission, by the great metallurgical interests of the United States, to investigate the whole subject, since it is believed that a better and cheaper artificial product can be made than any now in use, and that many other important incidental results would be accomplished by such an investigation.—*Brickmaker*.

feeling, are scratched or polished by the nail, can be cut into long ribbons with a knife, and appear somewhat like horn. When fresh from the quarry, they have a more or less fetid odor, owing to the presence of some partially decomposed organic substances. In composition they contain, as we have seen, either silica or alumina in excess. Silica in excess makes them rough, and takes away most of their plasticity and tenacity. Alumina makes them very plastic; magnesia makes them very unctuous, and almost soapy, but does not make them fusible; lime makes them dry and fusible; iron and other substances change the color, and, beyond certain very restricted limits, make them fusible. The gray and brown colors, up to black, are owing to a small percentage of bituminous material. White clays are generally considered the best, but there is no certainty about it, as they often crack, or even melt. It is generally an excellent sign when they leave unbroken lines when scratched by the nail. It is, however, never safe to judge by the eye or touch, as some of their chief characteristics apply equally well to materials not in the least refractory, and even those that are peculiar to them may be taken away by improperly drying them, by carelessness in storing or handling them, or by allowing them to become mixed with other substances. A preliminary analysis gives only a general idea of their nature, but it is not always a safe guide to the manufacturer, who needs first an analysis and then an assay, for some of the most inferior clays, if we should judge by their analyses, give excellent results when used as mixtures. Analysis is necessary both before and after the assay, but there is a molecular force which seems to have more to do with the value of the material than the chemical composition. The greater this force, the less likely is the heat to overcome it, either to cause disintegration or chemical union. If possible to do so, all clays should undergo some process of preparation, with a view of purifying them.

Every person using clays should endeavor to get a certain knowledge of their properties by assay. There have been a number of these assays published, most of which, though they give accurate results, are too complicated for ordinary use. The two simplest and best are the one prepared by Bischoff and the foil assay.

Bischoff's assay is based on the comparison of every clay with one from Garnkirk, in Scotland, which is taken as a type. For this purpose, the clay to be examined is mixed with one, two, three to ten parts of quartz, as the case may be. It is then raised to a known temperature and compared with a piece of the type clay of the same size and shape, which has been submitted to the same temperature. If the clay with three parts silica acts like the Scotch clay with one, it is called three, and so on. The best and simplest assay seems to be the one made by the blowpipe, which consists in mixing a small quantity of clay with water, and then spreading it out carefully on a piece of platinum foil in a very thin sheet, which, when completely dried, is submitted to the flame and compared with clay of known fusibility and prepared in the same way.

Very few clays can be used as found. They must be, as it were, suspended in some infusible material which will prevent, as far as possible, the mechanical effects of the heat, and allow, at the same time, of a certain amount of expansion and contraction, while preventing both in too great a degree. These materials are generally called "lean," that is, they do not make a paste with water, and require some binding material to keep them together. They are usually quartz sand or pulverized quartz, burnt clay, old bricks, serpentine, talc, graphite in powder, and not infrequently small coke, when the ash is not to be feared, and when graphite either cannot be had or cannot be used on account of its high price. Some fire clays from Spain contain this "lean" material, which comes from the decomposition of talc shale in which they have been suspended by nature, but this is a rare exception. The mixture must generally be made artificially. Of all these substances, quartz sand is the cheapest, but it has been found by experience that round grains of sand are less liable to become thoroughly incorporated with the binding material than the angular pieces of crushed quartz, so that when a very refractory material is required, crushed quartz is always used. As the clay contracts and quartz expands, a mixture may be made which will not change its form; but in a given case this may not be the best mixture for a special use. If the material has only to resist great heat, an excess of quartz is preferable; but if it must also resist the corrosive action of basic slags, clays burnt at a high heat, graphite or coke can be used. When the mixture is made in the place where it is to be used, without previous burning, it is generally made of one-fifth plastic clay and four-fifths burned clay or quartz, or one-fourth lean clay and three-fourths burned clay or quartz. This is done to avoid contraction. It is a most economical construction, even in blast furnaces, and is coming more and more into use.

(To be continued.)

[FROM SCIENTIÆ BACCALAUREUS.]

TALLOW CLAYS.

By Prof. W. H. SEAMON.

THE "tallow clays" found in Missouri are soft, unctuous masses of white, gray, pink, yellow, red, and occasionally black colors. As taken from the ground they contain a large excess of water, which they lose more or less rapidly on exposure to the atmosphere, shrinking and falling to pieces. During this operation, which is termed "slaking" by the miners, they lose about 30 per cent. of water, and change color, usually darkening.

The "tallow clays" occur associated with calamine alone, though sometimes small lumps are found near deposits of blende. We have lately received from Mr. Jno. Kingston, of Granby, Mo., an interesting specimen of an olive colored clay from Sucker Flat, near Joplin, which shows some cadmium. The miners of blende apply the term "tallow clay" to some impure kaolins found near the surface in their localities, but these do not possess those distinctive physical characters so well known to all who have ever handled the true "tallow clays."

The "tallow clays" are found in layers from a few inches in thickness up to several feet ("Geol. Survey of Missouri," 1873–74, p. 419, t. 499), in lumps of from a few pounds in weight up to several hundred, with calamine embedded in them, and in thin streaks in cavities in crystallized calamine. Many miners have told me that they usually find less calamine in those shafts in which they find large bodies of "tallow clay," which observation is confirmed by the experience of the superintendent of the Granby Mining Company. Sometimes calamine is found in slabs with and without a banded structure, as if it were a pseudomorph after tallow clay. The following specimens have been analyzed, with the results given below:

No. 1. A specimen from Granby, Mo., given me by Mr. John Kingston, slightly banded with layers of gray and buff tints.

No. 2. A grayish white layer from the mines of the Louisville Mining Company, at Aurora, Mo.

No. 3. A buff colored layer from same piece as No. 2.

	No. 1.	No. 2.	No. 3.
Zinc oxide	64·53	58·27	63·05
Iron oxide	0·07	0·05	1·97
Alumina	0·92	2·15	1·13
Silica	27·12	31·42	25·88
Water	7·36	8·11	7·98
	100·00	100·00	100·00

The undried specimens of tallow clay give off water in the closed tube; fuse on charcoal at about 3, always lightening up in color, becoming white or ash gray; give the zinc coating when heated in the reducing flame with soda; and are completely decomposed with gelatinization when heated with moderately concentrated hydrochloric acid.

The following analyses represent their average composition. The white varieties which have given such high results are found only in thin streaks and in small amount in the darker colored varieties:

ANALYSES OF TALLOW CLAYS.

(Specimens thoroughly air-dried.)

No.	Locality.	Color as Taken from the Ground.	Color after Drying in the Air.	S. G.	H_2O at 100° C.	Loss at low red heat, H_2O mainly.	ZnO	SiO_2	Al_2O_3	Fe_2O_3	CaO	$Na_2O + K_2O$		Totals.
1	Aurora	White	White	2·91	4·03	3·93	54·06	35·29	1·64	none	1·80	none	....	100·74
2	"	"	"	2·92	4·14	4·00	54·92	35·31	1·71	"	0·12	"	....	100·20
3	Near Peirce City	"	"	2·95	3·63	3·52	56·12	34·82	1·52	"	0·32	undet.	....	99·93
4	Granby	Gray	"	2·89	4·37	4·13	50·35	36·82	1·85	0·01	1·93	traces	....	99·46
5	Aurora	Flesh colored	Light drab	2·77	6·33	8·93	35·63	38·26	6·17	4·07	tr.	undet.	No P_2O_5	99·99
6	"	" "	" "	2·78	6·53	8·73	36·16	36·90	6·29	4·22	1·02	"	"	99·84
7	Near Peirce City	Cream	Yellowish	......	18·06		35·64	33·36	11·03	0·80	und	"	trace P_2O_5	99·89
8	Aurora	Light brown	Ash gray	2·47	9·38	9·22	36·38	36·50	4·92	1·89	1·77	none	CO_2 trace NoP_2O_5	100·14
9	"	Yellowish brown	" "	......	10·50	8·40	42·93	33·86	2·14	0·78	1·07	"	$NoCO_2$	99·77
10	"	" "	" "	2·57	9·62	8·36	30·03	37·34	10·62	2·06	1·36	"	"	99·40
11	"	Brown	Chocolate	2·99	7·00	10·38	28·56	43·49	5·16	4·38	1·21	"	"	100·17
12	Granby	"	Reddish brown	......	12·50	8·02	36·98	31·94	3·05	4·46	2·31	0·810	"	100·07
13	Near Peirce City	"	Pinkish yellow	......	10·44	8·19	34·83	34·21	7·91	4·89	0·02	none	"	99·90
14	Aurora	"	Chocolate	2.41	9·50	10·02	31·72	39·45	6·44	2·06	1·48	"	"	100·69
15	"	....	Reddish brown	2.72	6·76	9·70	32·35	37·11	3·44	9·54	1·06	traces	"	99·95
16	"	....	Brown	2.69	10·49	8·93	32·72	36·11	6·26	4·21	1·61	"	P_2O_5 0·020	100·34
17	Near Peirce City	Reddish brown	Yellow	2.25	10·78	9·93	34·40	37·66	3·88	3·36	0·01	none	NoP_2O_5	100·02
18	Granby	Red	Reddish brown	......	21·58		34·78	30·27	8·78	3·98	0·08	traces	traces of CO_2 & P_2O_5	99·47
19	Near Peirce City	"	Pinkish	......	20·15		25·96	34·94	9·92	8·53	tr.	"	P_2O_5 0·23	99·73
20	Granby	....	Pale yellow	......	16·83		34·83	35·07	14·26		....	....	....	100·99
21	"	....	Light brown	......	12·06		39·53	37·60	9·40		....	....	....	99·19
22	"	....	Brown	......	15·40		38·23	38·43	8·67		....	....	....	100·73
23	"	....	White	......	17·98		37·12	34·37	10·43		....	....	....	99·90
24	"	....	Brown	......	16·74		32·50	40·36	10·42		....	....	....	100·02
25	"	....	Pale red	......	16·11		32·34	42·08	9·64		....	....	....	100·17
26	"	....	" "	......	16·11		29·94	44·07	9·64		....	....	....	99·79
27	"	....	Dark brown	......	14·71		41·47	36·00	7·11		....	....	....	99·26
28	Aurora	....	Brown	......	17·80		36·12	35·20	9·98		....	....	....	99·10
29	"	....	Pink	......	18·30		31·54	37·37	12·89		....	....	....	100·10
30	"	....	"	......	14·25		37·39	34·67	14·37		....	....	....	100·68
31	"	....	Brown	......	16·73		37·84	34·45	10·84		....	....	....	99·86
32	"	....	White	......	12·72		48·93	35·94	2·40		....	....	....	99·99

The above complete analyses have been supplemented by determinations of zinc made by students in this laboratory of other specimens, and the results all tend to show that the "tallow clays" are uniformly quite high in zinc oxide, the air-dried specimens having approximately the following average composition:

Oxide of zinc	34·57
Silica	58·90
Iron and aluminum oxides	9·41
Water and other matters	17·12
	100·00

It is of interest, perhaps, to note that a similar clay has been found associated with zinc ore from southwest Virginia (see No. 1,144 *London Chemical News*) and in Spain (see Dana's "System of Min.," p. 408). I have also been informed that similar clays have been found with calamine in Colorado, but have not been able to verify the statement. From an article on the Zinc Deposits of Lehigh, Pa., published in the *Transactions of the American Institute of Mining Engineers* (p. 68, vol. i.), I take the following:

"A compact clay, containing from 26·32 per cent. of zinc, unctuous, and with an eminently conchoidal fracture, is believed by Prof. Ripper to be a true mineral."

These facts lead me to believe that the "tallow clays" are, or will be, found with every deposit of calamine throughout the world.

THE THIES PROCESS OF BARREL CHLORINATION.

By T. EGLESTON, Ph.D.

THE pyrites containing gold resulting from the concentration of free-milling gold ores is usually treated by Plattner's process, which was introduced into Grass Valley, California, in 1858, by Mr. G. F. Deetken, and has been successfully practiced there from that time. Various modifications of it have, from time to time, been suggested. Mears proposed to use chlorine gas under pressure of 30 lb. to 40 lb. to the square inch, made in a generator outside of the barrel and pumped into it, or produced inside the barrel by the use of a great excess of chemicals; and while it was found that more gold was dissolved, the gain was more than compensated for by the expense of the machinery, the great cost of repairs, the trouble caused by the leakage of the gas and consequent loss of the chlorine and inconvenience to the men. Davis proposed to precipitate the gold with charcoal, but no special advantage resulted from it. The precipitation is slow, and the difficulty of burning such bulky material in a muffle and treating the ashes before melting into a bullion, caused its abandonment. Mr. A. Thies, by whose advice the process was introduced at the Phœnix and Haile mines in North Carolina, and the Bunker Hill mines in Amador City, California, having had charge of the Mears process for more than four years, found that he could work without pressure pumps just as well as with them, as all the pressure necessary for the solution of the gold could be generated within the barrel just as well and much cheaper than by costly machinery; and after making a long series of experiments, leaving out of the Mears process all but the barrel, and having modified that so that there were no joints liable to leakage, in fact, so that there was nothing but the bare lead-lined iron cylinder left of it, perfected the process which is now known as the barrel process, but should be really known as the Thies process, which has been introduced at the Bunker Hill mine in Amador City, California, and at the Phœnix and Haile mines in North Carolina, where it has been working for several years very successfully.

Through the courtesy of Mr. A. B. Crocker, superintendent of the Bunker Hill mine, I had an opportunity to study this extremely interesting process at that mine. The details relating to the Haile and Phœnix mines have been forwarded to me by Mr. Thies. The Bunker Hill mine was located in 1882. It is situated 1½ miles north of Amador City. The vein dips at an angle of 75° and varies from 3 ft. to 25 ft. in width. It has two inclined shafts, one of which is 800 ft. long on the incline and 683 ft. deep from the surface in a vertical line. The south shaft is 400 ft. long on the incline and 345 ft. vertically from the surface. The two shafts are 360 ft. apart. The hanging is diorite, and the foot slate. The ore is quartz and black slate, with 2 per cent. of sulphurets, and is worth $5 to $6 to the ton. It is crushed in Hendy's modification of the Blake's crusher, which is run by a 4 ft. Knight's wheel under a pressure of 260 ft. of water. The mill is run by a 6 ft. Knight's wheel under a pressure of 270 ft. There is also a steam engine to use in case of failure of the water. The mill has 40 stamps. The ore comes from the mine by a tramway, and is dumped on to grizzlies, and falls from there to Hendy's rock breaker, 9 in. by 16 in., which does all the crushing. The movement is transmitted by iron arms from one end of the breaker to the other. The stamps weigh 850 lb., the stem is 350 lb., the shoe 150 lb., the boss 225 lb. The tappet is of steel and weighs 110 lb. The stamps make 92 drops of 6½ in., and each one crushes 2¾ tons in twenty-four hours. The order of the drop is 1, 5, 2, 4, 3. The screens are No. 8, and are ¼ in. angle slot, and last twenty days. The ore is amalgamated in the battery, and the splash plate is arranged in such a way that the pulp falls on to an amalgamated plate inclined away from the mortar at an angle of about 45°, then drops to another one inclined toward it, and then falls to the apron. This makes a fall from the screen to the first plate, and from the first to the second, and from the second to the sluice. The result of the constant impact is that little or no gold is found beyond these plates. The battery lip has two plates 8 in. long and 6 ft. wide. The apron is 3 ft. 6 in. long and 4 ft. wide. It has a grade of 1½ in. to the foot. It ends in a single sluice 14 in. wide and 12 ft. long, with a single silver plated copper plate. This ends in a pointed box for each sluice: 90 per cent. of the gold is found on the splash boards, 5 to 7 per cent. in the battery, and the rest on the plates. From the sluice the tails run on to frues, which make 220 strokes. From the frues the tails run on to dark sluices, of which there are fifty, 22 in. wide and 16 ft. long, exactly resembling the strakes of the Keystone mill. The pulp from this strake concentration is treated in pans with wooden shoes. The water used in the milling and on the concentrators is eight miner's inches under a 4 in. head. The cost of

milling is 60 cents. The number of men in the mill is five and in the mine seventy. Both miners and millmen are paid $2.75. The cost of water for milling is $1.60, and for power $18.40 per day.

The Bunker Hill and Phœnix works formerly used the Mears process, but were forced to abandon it because the cost of repairs was too great, and it was found to be impossible to keep the chlorine from leaking, and the men refused to work when they were exposed to such corrosive fumes. There seems to be no doubt that the use of chlorine under very high pressure acts efficiently, and since its abandonment the tails are higher, but the difference is not enough to pay for the extra trouble and expense. This seems, for the most part, to be owing to the use of dry ore and dry gas, no water having been previously used, but the whole difference is not more than $2 per ton, which it seems impracticable to save on account of the difficulty of keeping the chlorine from leaking. All of the Mears process has therefore been abandoned, and as now conducted it does not bear much relation to the original process.

The concentrates at Bunker Hill are 2 per cent. of the ore, and contain a trace of arsenic, antimony, and lead. Their average value is $60 to the ton. They are roasted with 1 per cent. of salt in a reverberatory furnace with a revolving hearth at the fireplace end. It is 40 ft. long and 12 ft. wide on the outside, with walls 18 in. thick. The stationary hearth is 7 ft. wide, 18 ft. long, and 24 in. high, and has two working doors, one on each side of the furnace. They are 8 in. by 16 in. At the end of the stationary hearth there is a drop of 6 in. to 7 in. The ore then falls on to a horizontal revolving hearth 12 ft. in diameter, with a discharge hole in the center. This part of the furnace is made of an iron shell lined with firebrick. It is 24 in. high to the crown of the roof, and 18 in. to the spring of the arch. The working door is 3 ft. above the floor of the roasting house. The bridge is 9 in. below the arch, and the grate bars 18 in. below that, so that the fireplace and combustion chamber together are 27 in. deep. This furnace is too small for any large output. The hearth revolves, by means of gear wheels beneath it, at the rate of one turn per minute. The work consists in turning the concentrates over and bringing them from the center to the circumference, and pushing them from the circumference to the center. When finished the charge is shoved from the center, through the hollow axis of the hearth, into the cub below, and from there the roasted ore is removed by scrapers attached to the bottom of the pan and loaded into iron cars and carried in them to the cooling floor. There are in the furnace three batches of 1,100 pounds of ore. One is on the end of the hearth nearest the flue drying, the others being roasted. The charges are moved every eight hours. The same charge remains only three hours on the revolving hearth. To ascertain whether the roasting has been sufficiently prolonged to decompose all the sulphates, a small quantity of the hot charge is thrown into water, and a bright iron rod thrust into it. If there is any undecomposed sulphate, the rod will be acted on; if not, the charge is ready for the barrel. The capacity of the furnace is two tons in twenty-four hours; 0·25 per cent. of sulphur remains in the ore after roasting. It requires one-eighth of a cord of wood, at $6 per cord, to the ton. At the Haile mine in North Carolina a double reverberatory furnace is used. They have just erected a Spence furnace to roast the concentrates.

The cooling floor is of brick, and is on the same level as the charging hole of the chlorinating barrel. The charge is generally made hot, but not sufficiently so to be burning to the hand. It is weighed and charged in iron wagons. The barrel-charging floor is of wood, in the center of which is a hole 2 ft. in diameter, into which an iron hopper fits. The barrel is on the floor below and has a manhole 12 in. in diameter, which is turned up underneath this hopper. The barrel is of cast iron, or sometimes it is made of boiler plate, and is lined on the inside with lead, usually weighing 10 lb. or 12 lb. to the square foot. All the joints are burned together when the lead is first put in. The lead used is ¼ in. thick, and weighs 12 lb. to the square foot. After five years of use at the Phœnix mine this lining shows no appreciable wear. The barrel is 4 ft. in diameter outside and 40 in. inside, and 6 ft. long outside and 54 in. inside. The heads are made of cast iron with the trunnions cast on them, and are fitted to flanges on the body. These are fitted with tight and loose pulleys. The lining must be well put in and with great care. It is fastened at once by bolts to the outside, as it has been found very difficult when repairs are required to burn lead on which chlorine has acted. There were formerly in the barrel, on the bottom, partitions of lead 2 in. to 3 in. high, which make the charge rise and fall out as the barrel revolves, instead of simply rotating around on the bottom. This has been found to complicate the construction of the barrel unnecessarily and has been abandoned without any perceptible change in the work. When the chlorinating barrel is turned up, 135 to 140 gallons of water are introduced from a wooden barrel at the side of the hopper by a pipe. The exact quantity of water is ascertained by marks on the inside of the barrel, and as soon as empty it is filled again to be ready for the next charge. The water must be in sufficient quantity to allow the pulp to flow easily, but it must not be too thin. One ton of roasted sulphurets is now added through the funnel, it having been previously thoroughly mixed with 25 lb. to 30 lb. of dry chloride of lime, which is the ordinary bleaching powder of commerce. This amount has been fixed on as the best, as it has been found that with a charge of 40 lb. no better results were obtained. When, as in some cases in North Carolina, the ore contains copper, more bleaching powder has to be used. The water is added first, because if the dry ore was added and then the water, the barrel would be more than full, as the two would not mix, but the ore falls through the water, so that the barrel is filled up to 8 in. or 9 in. of the manhole. What remains on its sides is then washed off the funnel with a little water. Thirty pounds of sulphuric acid at 66° B. are added after the rest of the charge is made. An excess of acid must always be used, so as to be sure to convert all the lime which remains on the hopper into sulphate, and the funnel washed free of acid, and then it is removed. In North Carolina the water is put in first, then the ore, and then the acid. The charge which answers best at the Phœnix mine, where the ore contains copper, is 40 of bleaching powder and 50 of commercial sulphuric acid. At the Haile mine, where the pyrites is free from copper, the charge is 10 lb. of bleaching powder and 15 lb. of acid. Half of each is used at the commencement, and after three hours' rotation the rest. The rotation is continued until free chlorine is present. When the charge is in, a rubber is placed over the manhole, and an iron plate over this, which is screwed down tight with a long lever as quickly as possible to prevent the escape of any chlorine from the barrel. The barrel is revolved at the rate of 12 revolutions a minute for four hours. At first the whole charge of chemicals was made at one time. This was found to not work advantageously, and now the charge is divided. Two charges are always made in a day. In North Carolina half the quantity required to generate the chlorine is introduced at first, and the rest at the end of half the time of rotation, and the process continued. The time of rotation of the barrel is from four to eight hours, depending on circumstances. When an examination shows free chlorine present, the operation is finished. It will not do to trust to pressure alone to determine the presence of chlorine in excess, for other gases are given off as well as chlorine, which would give a false indication if the operation was determined as finished by the pressure alone. A lead valve is arranged in the barrel, so that not only the pressure of an excess of chlorine gas, but its presence and the exact condition of the charge can be ascertained at any time. Where examination shows that there is an excess of free chlorine in the barrel, the pulp should be left in contact with it at least an hour before discharging.

The barrel is surrounded for two-thirds of its height on both sides by a splash box 18 in. wide, which ends in a trough which can be turned on to any one of the tubs. When the charge is finished, the barrel is turned up. The chlorinator, wearing a respirator, as there is considerable pressure of gas, loosens the screw of the manhole, so as to raise the rubber a little and allow the extra chlorine to escape for several minutes. He then removes the valve altogether, and with his hands turns the barrel down into the trough. The whole charge runs on to the filter, the bed of which is 6 in. in thickness. The filter is first flooded from below to the depth of 4 in. or 5 in. with water, and the outlet stopped. This prevents the charge from below from packing as the ore falls on to it. The barrel is then washed out with a little water, and it is ready for a new charge. The trunnions of this barrel, which was originally made for the Mears process, were made hollow for the purpose of introducing the stationary goose neck, through which the pressure of the gas in that process, which was from 30 lb. to 40 lb. to the square inch, was made and measured.

They were made too large in the first place, and are now very much too large. They have been stopped up with asbestos, as they are no longer used. In all the recently constructed barrels the trunnions have been cast solid. The difficulty with the barrel so constructed was the leakage of the stuffing boxes for the goose neck, which it was impossible to keep tight. Another and a greater one was the collapsing of the lead lining of the barrel from the exhaust, in the endeavor to collect all of the chlorine gas in the barrel which was not used in the chlorination, so as to use the gas in the next operation.

Another was the fact that there was often pressure due to the evolution of other gases than chlorine, which were mistaken for it, and the fact that, from mistakes as to the pressure, the ore supposed to have been fully acted upon by the chlorine had often not been sufficiently treated, so that the tails had to be worked over. The barrel is run by a 30 in. Knight's wheel.

The time necessary to revolve the barrel is not quite fixed, except by the work of the furnace. The total cost of power is $1 in twenty-four hours, or 50 cents per ton. As the furnace is small the quantity to be treated is small. Double the quantity might be treated if there was sufficient pyrites to treat. Two hours with the Bunker Hill concentrates would answer for the chlorination as well as four. The barrel discharges into three filter tanks, which are rectangular, 6 ft. by 8 ft., and 18 in. deep. They are lined with lead, and incline 1 in. toward the drain hole. The filter in California is made in them as usual, of quartz pebbles, gravel, and fine sand. To keep it in place and prevent its surface from becoming uneven, longitudinal slots 1½ in. deep and 10 in. apart are used on the top. In North Carolina the bottom of the tank is first covered with perforated tiles, which are covered with gravel and then sand.

They have two outlets for discharging into the settling tanks. When the barrel is entirely empty, the stopper in the tank is removed and the charge is allowed to drain, and is then washed with clear water, as rapidly as possible, until no gold is left. To do this the barrel charge is allowed to drain until the surface of the pulp is bare. The outlet is then closed and water is added until it stands 3 in. to 4 in. above the surface of the pulp. This is then drained. The outlet is again closed and the vat filled full of water, which will be from 9 in. to 10 in. deep. This is drained, and the tails will then generally be clean. They must, however, be examined, and the leaching continued if gold is present. The filtration is done very rapidly, but the time depends for the most part on the fineness of the ore. When the wash water contains chlorine but no gold, the tails will be clean. From 250 to 300 gallons of wash water are required per ton of ore treated. In six hours from the time the roasted pyrites is charged in the barrel the tails are clean and the filter ready for a new supply of barrel-treated ore.

The settling tanks are round, and are called stock tanks. There are three of these, 8 ft. in diameter and 4 ft. deep. They settle in fourteen to sixteen hours, and are drawn into the precipitation tanks, which are on a level below the bottom of the stock tanks. The precipitation tanks are 5 ft. in diameter and 3 ft. deep. In North Carolina they are 6 ft. to 8 ft. in diameter, and the same depth. They are quite large enough to hold all the wash liquors of three tons of roasted ore. There are six of them. The ferrous sulphate is siphoned into them. The solution must have a decidedly acid reaction, in order to be certain that all the lime has been converted into sulphate. Ferrous sulphate gives a bulky precipitate with neutral solutions of calcium chloride.

The solution is stirred with a wooden paddle and the ferrous sulphate added in excess. When the gold is all down, the ferrous sulphate is turned off, and the whole allowed to settle from forty-eight to seventy-two hours. The supernatant liquor is allowed to run out and a fresh charge introduced into the vat. The spent liquor is allowed to flow on to a sand filter covered with sacking. The sand is taken up once a year and chlorinated by itself. When copper is present in the ore, the weak solution, after the precipitation of the gold, is run over old iron, and then goes to waste. The sulphurets treated assay $55. The tails assay from $3 to $3.50. Occasionally they go as low as $1. The gold is collected carefully, washed to remove the iron salts, and melted as usual. When carefully done the bullion is from 990 to 995 fine. Sometimes it may go as low as 975.

It is a matter of surprise, considering the time and pressure of gas used, that this process does not bring the tails down as low as in the Mears process, where the roasted concentrates were moistened with only 15 to 20 gallons of water, whose only object was to prevent the roasted concentrates from dusting. The difficulty seems to be in the roasting. No salt was added in the Mears process, and the temperature of the roasting was much higher at the end. The explanation must be found in the roasting, as the wet gas does not explain the difficulty. No time, quantity of lime, or other change seems to affect the tails. The tails, when treated, are thrown into a trough in front of the tanks and sluiced out. Only one cord of wood a day is used in roasting.

The experience in these works has been that the tanks last best when the wood has been soaked in linseed oil, dried, and painted with tar or three good coats of white lead. The roasted sulphurets are worked up to 92 per cent. of their assay value. When, as they sometimes do, they contain twice their ordinary value, they are worked just as close, the tails in both cases never containing more than $3.50. When they were worked by Plattner's process in the usual way, the tails often contained as high as $7 a ton. The cost of this process, at Bunker Hill, per ton of roasted pyrites, is given below:

ROASTING.

Two roasters, at $3.25	$3.25	
Five-eighths cord of wood, at $6....	3.75	
	——	$7.00

CHLORINATING.

One chlorinator, at $3.............	$1.50	
Thirty pounds of bleaching powder, at 4 cents.......................	1.20	
Thirty-six pounds of 66 sulphuric acid at 3½ cents..................	1.26	
Twenty pounds of salt at ¾ cent....	.15	
Water power........................	.50	
General expenses and loss..........	3.00	
	——	7.61
Total for one ton of ore roasted and chlorinated.............		$14.61

The cost of doing this in North Carolina is very much less:

ROASTING.

Four laborers for roasting 2 tons of ore, at $1....	$2.00	
One cord of wood for roasting 2 tons of ore, at $1.25	0·625	
	——	$2·625

CHLORINATING.

Two laborers for 4 tons at 90 cents..	$0.45	
One chlorinator at $2..........	0.50	
Forty pounds of bleaching powder at 3 cents......................	0.30	
Sixty pounds of sulphuric acid at 2 cents	0.30	
Seventy-five pounds of sulphuric acid for ferrous sulphate at 2 cents..	0.125	
Repairs, wear and tear.............	0.20	
Power..............................	0.125	
	——	2.00
Total for one ton of ore roasted and chlorinated................		$4.625

The success of this process is undoubtedly owing to the formation of nascent chlorine in contact with ore, which is constantly being rubbed bright by the friction of the particles against each other and against the sides in the revolving barrel. In two years' use of the process at the Haile mine there have been no repairs. Under the conditions of the process it would be impossible for any coating forming on the particles of gold to remain on them, and if the gold is bright it is sure to be attacked, which might not be the case when the ore is treated in vats.

The solution and filtration are done so rapidly that there is little chance for the gold dissolved to be precipitated elsewhere than in the precipitation tanks. The advantages of this process are the small amount of space it occupies, the celerity of the operation, the high percentage of yield, the facility of ascertaining the exact condition of the charge at any time, and the very slight wear and tear. The only disadvantages are that a small amount of power is required to be used, which is not necessary in the ordinary Plattner's process, and that more than ordinary care and intelligence are required to run it.—*School of Mines Quarterly.*

THE TOXIC PRINCIPLE OF PYRETHRUM FLOWERS.

By Messrs. SCHLAGDENHAUFFEN and REEB.

THE active principle of pyrethrum flowers is an acid soluble in alcohol, amylic alcohol, ether and chloroform, which may be isolated by means of ether after having been converted into an alkaline salt and decomposed by tartaric acid in aqueous solution.

When pyrethrotoxic acid was hypodermically injected into animals, it was observed that the poison produced its effects in two distinct stages. In the first there was an excitement more or less pronounced, proportional to the quantity administered; in the second there was a complete prostration, accompanied always by paralysis of the lower extremities, which might disappear after a time, or be the precursor of a fatal issue, the respiration and circulation being affected only in the latter case.

SKETCHES IN BRADFORD, ENGLAND.

THE chief architectural feature of the town is the Town Hall. It stands on the site once occupied by the "Old Bowling Green Inn." When it was opened in 1873, the event was celebrated with great ceremony. It is right in the middle of the town, the principal streets leading up to it, and the tower forms a very striking feature in the center of Market Street, the chief thoroughfare. Its position is very advantageous, presenting as it does different views from all the main streets. The site is triangular in form. There is no large hall in the building, if the council chamber—a very fine room—is excepted, a large hall not being required, as the townspeople already possess a most commodious one in St. George's Hall, which can hold 4,000 people.

The interior of the town hall is entirely devoted to the purposes of the municipal offices of the borough, and for purely business purposes, including the borough court and police station. The ceilings of the court of the council chamber are elaborately decorated with gold and color, the panels of oak being painted with emblematical figures. The principal front in Market Street is broken by projecting gables at each end, and by the center entrance gable, and the clock tower rising immediately behind it. The second floor is divided into canopies between the windows, and also in front of the buttresses and pinnacles, and these receive statues of the kings and queens of England from the conquest to the present time, thirty-five statues in all, executed in the same stone as the building—white freestone from Cliffe Wood quarries—and each is seven feet high. Topping the clock tower is a belfry with thirteen bells, the largest weighing four tons.

They strike the Cambridge quarters and also play tunes every four hours, by three barrels of seven tunes each. Their sweet tones present a delightful contrast to the shrill whistles of the mills.

THE TECHNICAL SCHOOL, BRADFORD.

THE TOWN HALL, BRADFORD.

Bristling though it does with tall mill chimneys, Bradford is not satisfied. It pierces its often murky air with many towers. One of these surmounts the Technical School, perhaps the most completely fitted technical school for local manufactures in the country. During the winter season about a thousand students attend. The school is an imposing edifice, in the Venetian type of Italian architecture. It contains a public hall, class rooms, museum, library, and workshops for the dyeing, textile, and mechanical departments. Provision is made for evening classes to afford a sound commercial education, and to teach languages, shorthand, etc., to pupils engaged during the day.

The people of Bradford themselves are brisk and bustling. They all seem to take a lively interest in their town. They are keen to see what will advance its interests—of this the technical school is witness—and have a well deserved reputation of being shrewd, capable business men. Empty as the streets seem during the day, at night they are crowded with the workers from the mills, and the employes of the numerous warehouses who are close held during the day. Credited with being nothing more than a huge weaving center, Bradford is really full of historical and antiquarian interest. It has had a stirring history, and it is due to the indomitable pluck of Yorkshiremen alone that it has taken so large a share in British commerce.—*London Daily Graphic.*

A correspondent of *The Manufacturer*, writing to that paper, says:

Twenty-three years ago I visited Bradford, England, and was entertained for several days by one of the largest manufacturers of worsted goods for the American trade.

He has since died, leaving an estate of several millions of pounds sterling. At that time Bradford was a forlorn-looking town. The principal hotel was the Talbot Inn, and the only conspicuous building was the warehouse of Charles Foster & Sons, just completed.

After a lapse of twenty-three years I spent two days there this summer. The improvement had been so great that I found little of the old town that I could recognize. Foster's warehouse I saw, but there are now so many fine ones that it is no longer an object to impress one's mind.

A friend said: "I want to show you our new public buildings;" and remarked, "they are built with American money. In fact, the whole town is modernized from the profits of the American trade. It is an American town built in England."

The old Talbot Inn has disappeared. In its place is the Talbot Hotel, supplemented with more modern ones, the best of which are the Northwestern and the New Midland, just completed, and equal in appointments to the best hotels in the world.

I called on Mr. Tibbits, the American consul, and found him an affable gentleman, thoroughly posted as to the duties of his office and watching carefully the interests of the United States. He spoke of the enormous exportation of goods from Bradford for June, and said that the exports for July bid fair to be fully as great.

I visited a worsted mill in Bradford and asked the wages that were being paid. Young women were earning ten shillings, or $2.40 per week, against $7 for the same work here. Wool sorters, 24 to 26 shillings, $6 to $6.50. The boss sorter, $7.50. All less than half American wages.

STRETCHING OF LIQUIDS.

AT a recent meeting of the Physical Society, Prof. A. W. Worthington made a communication on the stretching of liquids. The three known methods by which this may be effected—viz., the barometer tube method, the centrifugal method, and the method of cooling—were described, and the precautions necessary in filling the tubes and in freeing the liquids from air discussed. With non-volatile liquids, such as sulphuric acid, the tubes are put in communication with a good pump, and before sealing, the liquid in the tube is kept at a higher temperature than that in the communicating vessel, in order that a stream of vapor may be passing outward and carry with it any air liberated from the glass during the process of sealing.

Before using tubes by the centrifugal method, the author finds it advantageous to subject them to considerable "jarring" at intervals. This usually breaks the liquid column, and liberates a small bubble of air, which may then be floated out. By repeating this many times, the adhesion of the liquid is greatly increased. With these precautions he had subjected water to a tension of 7·9 and sulphuric acid to one of 12 atmospheres. The cooling method of Berthelot (*Ann. de Chemie*, xxx., 1852) was then tried. In this method the liquid nearly fills a strong closed glass tube at a particular temperature. On slightly heating, it expands and fills the whole tube, any residual air being dissolved.

On cooling again, the liquid remains extended, and still fills the tube until at last it lets go with a violent "click," and the bubble of residual air and vapor reappears. The tension of the liquids tested under these circumstances has usually been calculated from the relative change of volume, on the assumption that the coefficient of extensibility is the same as that of compressibility. The author exhibited and described an apparatus by which the tension and the extension can be measured simultaneously. The tension is ascertained from the enlargement of the ellipsoidal bulb of a thermometer sealed into the containing vessel, and the extension calculated from the volume of a bubble after the click. The tension thermometer had been calibrated by internal pressure, and in determining the extension, correction is made for the change of volume of the apparatus. By this method he had subjected alcohol to a tension of seventeen atmospheres, and found that the coefficient of extensibility is much less than that of compressibility. It is not clear what causes the liquid to let go of the glass, but it is found that the bubble can be caused to reappear by passing an electric current through a wire sealed in the capillary tube. Sir Wm. Thomson remarked that Prof. Worthington's paper was a curious commentary on the usual mathematical definition of "a liquid" as a substance which offered no resistance to being separated into parts.

Speaking of freeing liquids from air, he said the beneficial effect of jarring could easily be shown by tapping an ordinary "philosophical hammer;" separation of the column always leaves a bubble which can then be floated off. He had also found that, in freeing liquids from air by boiling, it was advantageous to have a long escape tube, so that part of the liquid condenses and runs back.

ON THE RESISTANCE OF OILS AND RESINS TO THE PASSAGE OF MOISTURE.

By A. P. LAURIE, M.A.

THE experiments of Capt. Abney and Professor Russell on water colors have shown that many pigments fugitive under ordinary conditions are permanent in dry air, though exposed to sunlight. It is therefore of importance to know what mediums used for painting protect a pigment absolutely from moisture, and what allow moisture to pass through. This is of special importance in the painting of pictures when durability is required, but may also have some bearing on the commercial use of oils and resins to protect surfaces. My attention was the more directed to this subject, as I found receipts in 15th century MSS. for the preparation of such fugitive colors as Brazil wood lakes, which must, to account for the remarkable state of preservation of pictures by the old masters, have been carefully locked up from moisture. I determined, therefore, on some experiments to discover how far ordinary oils and varnishes could be held to protect a pigment from the action of moisture.

With a view to testing this, I ignited pure sulphate of copper, obtaining the white anhydrous sulphate. Using this as a pigment, I ground it with oil and painted it out on three glass slides. One I exposed to the air near an open window, one on the mantelpiece of a warm room, and one placed in a desiccator. In 12 hours the slide near the open window was green, the slide in the warm room was slightly green, and the slide in the desiccator was still white. On now exposing all three to the air near the window, they all turned completely green in another twelve hours. I had evidently here a delicate method of testing the permeability to moisture of such vehicles. I therefore experimented as follows:

The sulphate of copper having been ground with the vehicle to be tested, and painted out on a glass slide, it was next placed in a desiccator to dry. When quite hard, it was then either placed under a bell jar containing a dish of water or exposed to the air of the room. In most cases a duplicate slide was made and was kept in the desiccator for comparison. It would be tedious to recount all the experiments, and I merely give the results.

I first compared pale boiled oil, best copal oil varnish, amber dissolved in oil, amber dissolved in turpentine, common resin in turpentine and mastic in turpentine.

The amber in turpentine remained unchanged.

The other turpentine varnishes turned an opaque bluish-green.

The oil and oil varnishes turned a transparent pale green.

On next examining these slides under the microscope a curious difference presented itself. In the case of the oil and oil varnishes, a uniform change had taken place, the copper sulphate being apparently completely hydrated, and here and there perfect crystals of sulphate of copper could be seen.

In the case, however, of the turpentine varnishes, the surface consisted of planes of unaltered sulphate, with cones of sulphate of copper crystals rising here and there on the surface, making the whole surface rough as seen under the microscope. In only one case out of three the amber in turpentine showed a similar appearance over part of the surface.

Apparently, then, the resins when dissolved in a volatile oil do of themselves protect the sulphate of copper from moisture, but tend to form holes and cracks through which moisture enters. Amber in turpentine, however, seems to be free from this tendency. On the other hand, linseed oil, whether mixed with resins or not, seems to be permeable to moisture over the whole surface with such completeness as not to cause the formation of rough projections of crystals.

It next seemed of importance to test how far the linseed oil when dry could be protected by coating with a resin dissolved in turpentine. I therefore prepared slides with linseed oil, and when dry, coated with (1) amber in turpentine, (2) copal in turpentine, (3) mastic in turpentine, (4) copal in oil. After drying and twelve hours' exposure to moisture, (1) and (2) were covered with green spots, but (3) and (4) unchanged. Under the microscope these spots were round in outline, with sulphate of copper crystal cones filling them. In three or four days all the slides were green. Apparently, then, a resin in turpentine does not protect linseed oil, and the better the resin the more likely it is to be pulled into holes, doubtless owing either to capillary forces or to different expansions of the two layers.

It seemed next of some importance to decide how far the preparation of the linseed oil would affect the result. I therefore obtained the best seed, had it picked over, cold-pressed, refined over water in sunlight, and converted into boiled oil with borate of manganese. In some of this oil I dissolved amber, and in some copal. I also had a very fine specimen of commercial copal varnish, and two good samples of commercial boiled oil, megilp, an artist's medium, from a good maker, another pure linseed oil slightly differently prepared. These I tested in various ways, sometimes mixing a little varnish with the oil, sometimes using the varnish pure, sometimes allowing the slide to dry, then varnishing with the same medium and drying again before exposure.

None of these combinations resisted the action of moisture, nor did they differ greatly in the rapidity with which the change took place. On the whole the pure oil usually stood longer than the commercial oil, and the presence of a little varnish, especially amber varnish, seemed to preserve it a little longer still. But the results were uncertain, the method not lending itself well to comparative tests of this kind, as the thickness of the layer of oil of course affects the result.

One result of interest was, however, obtained, and that was that the power of linseed oil to resist moisture is immensely improved by keeping the slide for some time after the oil is dry, every week in the desiccator improving it in this respect.

As far, then, as the evidence goes, resins in volatile oils resist the passage of moisture in themselves, but tend to become full of holes and cracks, amber resisting best in this respect.

No vehicle containing linseed oil resists the passage of moisture unless possibly by long keeping. (This point is under examination.)

If such painters as Van d'Eyck had a medium which protected colors from moisture, as apparently, judging from their pigments and pictures, they had, it remains to be discovered.

The method should prove useful in testing preparations meant to absolutely protect surfaces from moisture, with a view to finding how far they may be trusted to do so.—*Jour. Soc. Chem. Industry.*

ELECTRIC SHARPENING OF FILES.

WE have already spoken of an interesting application of electricity to the sharpening of tools without grinding or retempering. The extension that has since been given to this process, which has recently been adopted by the minister of war, leads us to return more in detail to a question that interests a number of trades.

The inconveniences attending the recutting of a file or rasp by hand are well known. In consequence of the operations that it necessitates, the tools are rendered notably thin, and even crack, and always become decarbureted. Besides, it is often almost as costly to recut a tool as to replace it. So an endeavor has been made to substitute for the usual method of recutting the use of chemical processes capable of restoring to a tool the cutting edge destroyed by use. But all such attempts have ended in a mere cleaning of the tool, and in giving it a temporary sharpness obtained by quite costly means.

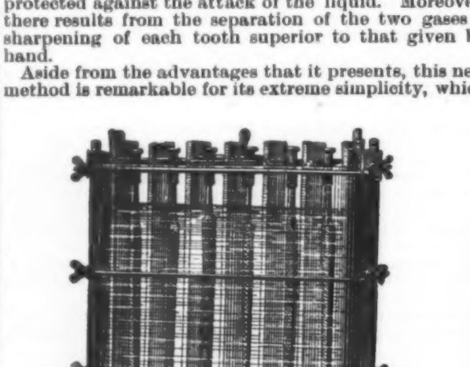
Recutting by hand could only be abandoned through a solution of the following problem:

How shall we restore to the tooth of the tool its initial length, and at the same time sharpen it, without modifying the steel?

Mr. A. Personne, of Senneroy, the inventor of the new electric process, has solved this interesting question as follows:

His process consists in forming a carbon and acidulated water battery in which the tool to be sharpened forms the anode, the circuit being closed directly between the carbon and the tool. Under the influence of the electric current, the water is rapidly decomposed into its elements, each of which then performs a totally different role. While the oxygen proceeds to the bottom of the furrows, which it gradually deepens, the hydrogen forms, in a nascent state, a covering of small bubbles over all the projecting parts, which are thus protected against the attack of the liquid. Moreover, there results from the separation of the two gases a sharpening of each tooth superior to that given by hand.

Aside from the advantages that it presents, this new method is remarkable for its extreme simplicity, which



BATTERY FOR SHARPENING FILES.

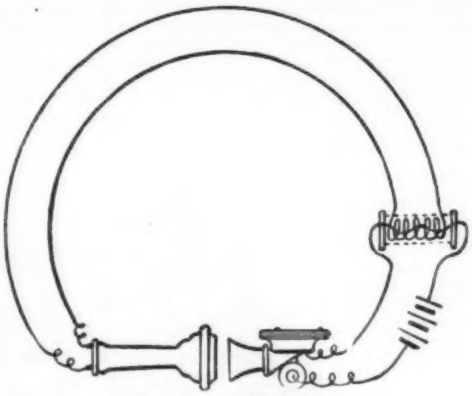
permits of introducing it anywhere at slight expense.

In the accompanying figure we reproduce a photograph of a complete battery for the treatment of a series of files. A child in charge of this apparatus can sharpen about twenty files an hour.—*Le Genie Civil.*

A CURIOUS TELEPHONE EXPERIMENT.

SOME weeks ago, while Messrs. Hibbard and Pickernell, of the American Telephone and Telegraph Company, were experimenting on a line between Ithaca and Cortland, New York, the following curious action between the telephone and a long distance transmitter was noticed. Mr. Pickernell was engaged in talking on one pair of wires, while Mr. Hibbard was listening on another pair on the same pole line, 20 miles away. Both circuits were equipped with transmitters and receivers. Mr. Pickernell's voice came in on circuit No. 1 by direct transmission so as to fill the room, and, in fact, made such a noise that Mr. Hibbard was unable to listen for traces of induction on circuit No. 2. Doubtless the patrons of the long distance service will appreciate such obstreperous transmission, but in this case the receiver on circuit No. 1 must be strangled or the test could not go on. To do this Mr. Hibbard placed the offending receiver against the mouthpiece of the transmitter on the same circuit so as to close it up and prevent the escape of Mr. Pickernell's voice into the room, when, lo! a shrill and sustained musical note of high pitch was emitted, which drowned all other sounds. The pitch varied occasionally through an octave, but was exceedingly uniform in volume, and did not break while the telephone was held against or near the transmitter. The explanation of this action is as follows:

The vibrations starting in the transmitter actuated the telephone through the primary and secondary circuits, the telephone throwing the impulse back to the transmitter through the air volume separating the two instruments, the transmitter reacting as before, the impulse acting with sufficient rapidity to form a musical note.



MUSICAL TELEPHONE.

We believe this is the first recorded observation of "back talk" between a telephone and transmitter. The energy for maintaining this action is stored up in the battery, which must be in good condition. The accompanying diagram shows the simplest method of accomplishing this result.—*Elec. Review.*

[Continued from SUPPLEMENT, No. 768, page 12273.]

ELECTRICITY IN WARFARE.*

By Lieut. BRADLEY A. FISKE, U. S. N.

RANGE FINDER.

IT has been mentioned before as a prime necessity of effective gunnery at sea that the gunners shall know at each instant the exact distance of the ship at which they are to shoot. To realize this we must reflect that, if two ships are approaching each other at the rate of even twelve knots each, their distance apart is changing at the rate of thirteen and one third yards per second. This means that in less than four seconds the distance or range will change fifty yards, which represents the distance apart of two consecutive graduations on the sight bar of a modern rifled gun. In other words, the sight bars of high-powered guns are usually graduated to fifty yards, and it is necessary for effective shooting that an error as great as fifty yards must not be made in estimating the distance, and timing the discharge of the gun, as the ship rolls from side to side. But if this change of fifty yards is made in four seconds, we see that we must have an instrument which will give the range with less than four seconds delay, and give it at the very least with less than fifty yards error. Such an instrument is called a range finder. It may be objected that, if you close with your enemy to "point blank range," as it used to be called, or say about 500 yards, then you can fire away as fast as you please, and the flight of the projectile is so nearly horizontal that you do not need to know the range.

This is perfectly true, but it should borne in mind that, if the enemy's ship has a range finder, he can begin at 2,000 yards at least to deliver a careful and accurate cannonade with heavy shell, and inflict tremendous damage on you while you are waiting for close quarters. Moreover, as soon as he discovers that you want to close, he will at once, and for that reason, try to defeat your plan and keep you at a distance, all the while pouring in his merciless fire.

Perhaps a few words of description of the newest range finder will not be out of place, especially as it has a number of features interesting from a scientific point of view. All know that every calculation of distance depends upon solving a triangle, in which a base line is known, and two angles at its ends are measured, these angles being included between the base line and lines drawn from its ends to the distant object. In surveying, theodolites are placed at the ends, and the angles are read from their graduated limbs.

In this range finder, a German silver resistance wire replaces the graduated arc, while a receiving instrument, which is in fact a rheostat, sums up automatically the angles. The base line being a constant, the receiving instrument is marked in yards at once, instead of in angles. The operation of using the range finder, then, is this—two observers at opposite ends of the base line gaze continuously at the distant object, using telescopes preferably. They do nothing else. But a third observer, watching a galvanometer, simply moves a contact bar along a resistance wire on the receiving instrument in such a manner as to keep a galvanometer needle always at zero. His contact bar then points at the correct distance. If the object be moving, it makes no difference. The operation is as easy as if the object were stationary, and the indications are instantaneous and continuous. With a 290 foot base line on board the U. S. S. Chicago, one instrument being mounted in the bow and one in the stern, the

* A lecture delivered before the Franklin Institute, January 20, 1890. From the *Journal*.

average error in the official trial was six tenths of one per cent., and no difficulty was found in continuously reporting the distance of moving vessels.

POSITION FINDER.

Closely related to range finding is position finding, in which not only the distance of an object is obtained, but its exact position. It has been the practice in the forts of all nations to divide the harbor or other adjacent water into imaginary squares about 100 yards on a side, these squares being marked on a chart and numbered. Somewhere within or near the fort is a carefully measured base line, and at its ends are two telescopes or alidades, connected together by telephone, telegraph, step by step apparatus, or other means.

At some sheltered spot is the chart above mentioned, over which two pointers are arranged to sweep, being pivoted at the points representing the two telescopes. Now if the observers at the telescopes keep the officer at the chart constantly advised as to how their telescopes are pointing, he simply moves his pointers to correspond, and the intersection of the pointers on the chart represents the object at which the two telescopes are directed. Noting the square upon which the pointers intersect, the officer telephones or otherwise signals to the guns to fire at square 110, 125, etc. Then the officers at the guns train and elevate their guns so as to fire into those squares, having at hand tables to direct them how to so train and elevate. It will be observed that guns can thus fire at a target when the smoke at the guns is so thick that the gunners cannot see the target. But Major Watkin, of the Royal Engineers, has improved upon this method, and very greatly. The details of his invention are guarded strictly, but some of the results are known. They are simply diabolical. Gunners who could not see a target, and did not know how far off it was or where it was, have put forty-five per cent. of hits on the deck of an imaginary ironclad at ranges of from 3,000 to 4,000 yards, or from one and three fourths to two and one half miles. Perhaps in the course of a few months we shall hear of a position finder invented nearer home.

All the guns of a fort can be fired with marvelous accuracy by an officer distant from the smoke, noise and confusion of the battery, but connected with observing stations so located as to command a good view of the vicinity.

FIRING GUNS BY ELECTRICITY.

A very great increase in the accuracy of gunnery at sea is secured by the plan now coming into use in all civilized navies, by which the guns are discharged by electricity. The general idea is not new, but it is only of late that it has been made thoroughly practicable.

By the old plan the gun captain ordered "right" or "left," and the sailors hauled the gun to the right or to the left. Or he ordered "raise" or "lower," and the sailors raised or lowered the breech of the gun. When he got the gun nearly right, the gun captain called "ready," and everybody got clear of the gun in order not to be injured by the recoil. When the motion of the ship brought the gun sights in line with the target, the gun captain pulled lustily on his lanyard, and the gun went off. But under the new system one of the sailors moves a small lever to the right or to the left, as explained above, so as to keep the gun pointed all the time in the direction of the target.

The gun captain holds a small circuit closer in his hand, and as soon as the rolling of the ship brings the sights level with the target, he simply presses his fingers, without bothering himself to see if the men are away from the gun, because the recoil will not hurt them. Knowing the exact range, and having this quiet and simple means literally at his fingers' ends, what is to prevent a gun captain from hitting the target?

It must be borne in mind that the real errors in shooting at sea are not in shooting to the right or the left of the target, but in shooting over it or short of it. This shooting over or short arises from two things: First, having a mistaken idea of the distance. Second, firing too soon or too late when the ship is rolling. Now a range finder eliminates the first error, and electric firing goes a great way toward eliminating the second error, principally because it obviates the necessity for making any allowance for delay in the firing of the gun after the gun captain has done his part.

Electricity discharges a gun at the instant when the gun captain presses his fingers, and not at some other time. So that if a gun captain, having his gun set at the correct range, presses his fingers when the sights are in line with the target, he will hit the target. Of course, errors of eyesight cannot thus be eliminated, neither can the errors of the gun. But both of these are exceedingly small, so small compared with the other errors that they are inconsiderable, as has been abundantly proved.

MARINE PROPULSION BY ELECTRICITY.

The question is often asked: "Is marine propulsion by electricity one of the probabilities of the future?" The only way to answer this query is to decline to attempt the role of the inspired prophet, for while one would not have the hardihood to say that it will never be (remembering the solemn promise of a celebrated English scientist to *eat* the first steamer that should cross the Atlantic), yet on the other hand one would hardly dare to assert that it will be. The question is merely one of practicability. At present electric marine propulsion is not practicable, except on a small scale, but the difficulties in the way are of the nature often overcome by persistent experiment and by the improvements resulting from slow experience.

ELECTRIC LAUNCHES.

It can be definitely stated, however, that electric launches are so near a practical success that one does not need to be a prophet to discern their coming in the near future. No less an authority than Prof. George Forbes declares that they are already a practical thing on the Thames for a certain class of boats, in which great speed is not essential, but in which quiet, easy motion and cleanliness are desirable. He further states that in his boat he has got a return of nearly sixty per cent. of the horse power put into the storage cells in absolute power of the propeller. Some of the storage cells now in the market are quite durable, if not overdischarged or shaken up. I have a battery of thirty cells, of the size known as 7 M, which have been used in developing the range or position finder mentioned above, and they have fulfilled the purpose exactly. They were originally charged last July, and they did not have to be recharged until a month ago. They were used on board the U. S. S. Chicago for some months, and were subjected to a good deal of rough treatment, being moved about the decks a good deal, lowered down into a store room, and hoisted up on deck again a number of times. Besides this the sailors spit tobacco juice on them, and then played salt water on them with a hose, to wash them. The sailors called the case containing the cells "the box of electricity." At first they looked at it with the contempt which every true man-of-war's man feels for anything scientific, but they generally acquired for it a certain respect, as time went on, and they saw what curious things the ugly black box could do.

One of the newest electric launches is the Magnet, 28 feet long and 6 feet beam, drawing 2¼ feet of water. She carries fifty-six accumulators, weighing 2,400 pounds, or about as much as fifteen men, and these accumulators furnish the energy to drive an electric motor whose armature is on the same shaft with the propeller. It is claimed that this boat can carry twenty people in smooth water, and that she can go eighty miles at a speed of six to eight knots, or go a shorter distance at a speed of eight to ten knots. It would seem as if, even at the present stage of development, such a boat would be valuable in a war ship, from the fact that it can be got ready for service instantly, and can go faster and longer than an ordinary man-of-war's boat pulled by oars.

ELECTRIC PICKET BOATS.

It could do excellent work, for instance, in case of a fleet at anchor, in carrying dispatches from ship to ship. The cells in the boat could be charged while the boat was lying alongside, or even when hanging at the davits; and in such emergencies as are constantly occurring in naval life, it could be lowered and started off in a few seconds; while for scout duty or lookout duty, what other boat could be so noiseless and swift?

ELECTRIC SUBMARINE BOATS.

Closely allied to electric launches are electric submarine boats, in which also the energy needed for propulsion is carried in storage cells. The newest vessel of this class, about which much is known, is the Spanish submarine torpedo boat Peral. Trustworthy details are hard to get, but there seems to be no doubt that she can remain under water for hours, can move at a high speed both above and below water, and that she can carry enough energy in the storage cells to enable her to carry out any attack which a submarine boat is intended to make, *i. e.*, a sortie from a harbor upon an attacking fleet.

ELECTRIC COMMUNICATION BETWEEN SHIPS AT SEA.

I fancy that everybody here is aware of the fact that the great need of all navies is a quicker and more trustworthy means of communication between ships at sea. Doubtless most of you know also that many experiments have been made looking to the establishment of a means of communication by electricity. Two general lines of experiment have been followed. In one sound vibrations are set in motion in the water, and are received on a diaphragm, usually on the underwater side of a ship, this diaphragm corresponding to a telephone transmitter, the receiver being in the pilot house or other convenient place. The other line contemplates sending electric signals through the air or the water, the receiver being usually a telephone receiver. During about two years a great many experiments were made at the New York Navy Yard in the latter line, signaling both through the air and through the water. These experiments were on a pretty large scale. A large dynamo was used as a source of power, and in one case the U. S. S. Atlanta was converted into the largest electro-magnet known, being wrapped with heavy wire, through which the dynamo current was sent, while the iron tug Nina, 150 feet long, was made a receiver, she being wrapped with fine wire having a telephone in circuit. But the most satisfactory results were got by sending the impulses through the water, and though nothing quite practical was reached, yet one felt all the time that it was because he was not prosecuting the experiments correctly. These experiments seem worthy of mention, because they indicate one of the few fields of electrical engineering not yet explored.

ELECTRIC SIGNALING.

But electric signaling by lights is already a practical thing, and is used in all navies. It is not the ideal thing, and does not attempt as much as the plans above mentioned. But it is a great improvement on the old plans, and can do good work with skilled operators. The plan most employed is to make and break the circuit of incandescent lamps, and thus signal letters and words according to a preconcerted code. But when distant signaling is desired, between points ten miles apart, for instance, or when high land intervenes, then the penetrating ray of the search light is flashed into the sky.

In conclusion, if we compare the art of electricity in warfare at its present stage with that prevailing five years ago, we shall see that a comparatively unimportant thing has grown to be an important thing, and that scientific apparatus is employed much more than it was then.

NECESSITY FOR EFFICIENT EQUIPMENT OF WAR SHIPS.

Now this indicates the tendency in modern warfare, a tendency to accomplish a desirable end by any effective means, no matter how complex or how expensive. Certain objects must be attained. If a ship is to go into a fight, she must whip. A lost battle is a national regret forever. A single ship, a small one perhaps, like the Kearsarge, may fight a battle, of which the consequences will be altogether out of proportion to the money value of the ship. There are thousands of buildings in this country that cost more than did the little Kearsarge; but suppose this cheap little ship had been sunk by the Alabama. The thought is unendurable. Now every nation feels that each of her ships is an exponent of what she can do in that tonnage, and while no nation feels bound to build ships each one of which can whip any ship in any other navy, she does feel bound to build and equip each ship well enough to whip any foreign ship of her size and weight. So modern ships are coming to be the foremost examples of the application of science to practical things.

TENDENCY OF MODERN WARFARE.

The sailor is still a sailor, and will always be a sailor, so will the soldier always be a soldier. The profession of arms, whether on land or sea, calls for and develops certain qualities of mind and heart. Endurance, decision and chivalric courage will win battles in the future, as in the past. The grand principles of strategy persist, and so do the laws governing the command of men. Yet the *conditions* of warfare are changing. Simplicity is giving place to complexity. Woe to that nation which fails to note the signs of the times. War is a serious thing, but it is more serious to the vanquished than to the victor. It behooves every nation to see that by no chance shall it be vanquished. No means of offense or defense must be neglected because it seems too delicate or too expensive, provided only that it can be made to be efficient. Science is daily coming more into our lives, as the number of those who study her increases; but in no department of life is she making more progress than in warfare; and in warfare no branch of science is making more progress than electricity.

[FROM THE FARM JOURNAL.]

A CONNECTICUT PEACH ORCHARD.

By J. H. HALE, South Glastonbury, Conn.

SIXTEEN THOUSAND BUSHELS OF PEACHES FROM THIRTY-FIVE ACRES.

I.

ALLOW me to state I am a *working farmer*, not yet past forty, am living on and cultivating a farm that has been owned by my family for 250 years. Father died when I was less than two years old, leaving a widow and four children with no income except what could be had from the farm, therefore had to begin work early in life and later on study how to make that work pleasant as well as profitable.

Horticulture seemed to offer the best solution of the problem, and before I was ten years old, myself and brother, three years older, had one of the then very few fields of cultivated strawberries in the State.

From year to year the field was enlarged and the various other small fruits added, and although the highest and best culture was always given, the greatest profits mostly came from new or rare varieties, or from the culture of those that others found difficult, and so abandoned, and gave us the whole market for them.

A knowledge of this led to a study of the peach, the culture of which had been abandoned in this section of the country, owing to yellows in summer and frosts in winter killing out most trees before they could reach a bearing age.

A few years of close observation and study convinced me of four things: 1st. That trees grown in rich gardens or in cultivated fields where stable manure was used made a too rapid and too tender wood growth, and if the tree itself was not killed, the fruit buds were likely to be each winter. 2d. Trees growing in uncultivated lands and along fence rows made a much stouter growth and were far more hardy in tree and fruit buds, yet never produced any first-class fruit and soon died of yellows. 3d. In back up-hill lots, where it was difficult and costly to cart stable manure, and therefore ashes and superphosphates were used for corn crops year after year, trees along the fence rows were usually healthy and produced several good crops, and in a few cases where the ashes had been applied directly to the trees, larger and higher colored fruit had resulted. 4th. Even if healthy trees were here and there secured, those in the valley or on the flat plain lands higher up would have their fruit buds killed at least four years out of five, while trees on high rolling lands would pull through about half of the time.

With these points in mind as *half settled facts*, operations were begun in 1877, by securing a lot of pits from old and healthy seedling trees I had found in Tennessee two years before. The seedlings thus produced were budded from healthy bearing trees, and thus what seemed to be a right start secured. Land selected for planting the orchard upon was a hillside sloping to the north and west, which after being in pasture for many years had produced three alternate crops of corn and rye with only wood ashes for manure; consequently was quite deficient in phosphoric acid and nitrogen. Naturally, however, the soil was a good, strong sandy loam, with a slight admixture of clay.

In early spring, when ready for planting, this was thoroughly plowed and harrowed and put in the best possible shape as regards pulverization of the soil, checked off in rows 15 x 15 feet, holes for the trees were dug 3 ft. across and 2½ to 3 ft. deep, and then refilled to within a foot of the surface with surface soil, with which was mixed two to three pounds of very fine ground raw bone. Trees having been brought from the nursery, a sharp pair of pruning shears were used to cut off all bruised or broken roots, and all side branches of the tree, which was then headed back to two and one-half feet, so that when planted about one inch deeper than it had grown in the nursery row, there was nothing but a bare cane standing for the future tree. About 1,000 trees were thus planted. Around these a foot or more away from the base of the trees was then spread 2½ to 3 pounds of high grade muriate of potash.

How to keep out the borers was the next question. A wash of whale oil soap was recommended, but inquiry showed it to be somewhat expensive; therefore, two quarts of crude carbolic acid was mixed with six gallons soft soap, and then water and lime enough added to make a thick wash that would adhere to the tree. An old rag tied on to the end of a small two-foot stick furnished a swab for applying the wash to the base of the trees.

Branches having all been cut away at time of planting, soon as growth begun new shoots sprang out all along up the body of the true. Before any of these were two inches long all were rubbed off except three or four within a foot of the top, which were left at a distance of 3 to 6 in. apart, and in such position as to form a new and well balanced head for the tree.

Cultivation with a harrow was begun early, so as to get ahead of the weeds, and was kept up often enough

to keep down all other growth except the trees, which had full possession of the land from the start.

Cultivation ceased the middle of August except on one-quarter of an acre, where it was continued till October. The branches of the trees on this section made from six inches to a foot more growth than the others that fall; but as the trees were badly injured by the freezing of winter, while those where cultivation ceased in August were uninjured, it was a lesson we were glad to learn. In the fall, just before the frosts of winter set in, all the trees were banked up a foot or more with earth at the base of each tree, partially to hold them in position against the swaying of the wind and partially to prevent injury from mice working under the snow. This earth was leveled down early in spring, and each tree carefully trimmed by first thinning out all crowding small branches, and then shortening in the main ones one-third to one-half of the last season's growth.

The first year's work had been done without any well defined plan of action or any definite knowledge of what was best and right to do, except, as has been before stated, such knowledge and inferences as could be drawn from a few years of close observation and study of the few trees that were scattered about the town and country. The start, however, had been successfully made, and it was determined to plant 3,000 more trees this second spring, leaving a few hundred of them for experiment, planting and treating the rest exactly the same as the first orchard had been started.

With the trees to be planted for experimental purposes it was proposed to attempt to settle these questions: 1st. Does the use of potash really have anything to do with the health of the tree and its freedom from the disease called yellows? 2d. Is stable manure or highly nitrogenous commercial manure injurious to the health of the tree in this climate? 3d. Other conditions being equal, is high or rolling land more reliable to plant on than comparatively low or flat land? 4th. Is our borer wash of any real benefit? Possibly it may be just as well right here to follow out the results of these experiments.

To test the potash question, 100 trees were planted and treated in all respects like those in the large orchard, except that no potash was applied for the first two years. There was little difference between these and the trees receiving potash. The third year there was a falling off in the growth and a general lack of vigor noticed. This was more marked the fourth season, when some signs of yellow appeared. This was greatly increased the fifth year, when the trees were bearing a partial crop of fruit. Two of the worst cases, that had prematured their fruit, were closely shortened in, and an application of 15 pounds of muriate of potash given each tree in September.

Early the following spring some eight or ten pounds of nitrate of soda were given each tree, in three applications, at intervals of two weeks (this to stimulate the trees into a very rapid new growth, which it did), and by midsummer they were growing rapidly and had foliage of the darkest hue. In August they were given another heavy dose of potash; all the rest of the orchard died out by the end of the seventh year. These two trees produced perfect crops of fruit the eighth and tenth years, went into winter quarters in apparent good shape, but were dead the next spring, caused by the yellows or what I do not know; but the fact remains that after having once prematured their fruit, heavy doses of potash braced them up, and enabled them to live on in apparent health for four years, and produce two crops of perfect fruit.

In testing the second question, less than twenty-five trees were planted on land that had been for years well enriched with stable manure, and liberal applications were made each year, trees made an enormous growth, were somewhat injured by freezing the third winter, and all died of yellows the fifth year. Another small block was treated with bone and potash, supplemented by four or five applications of nitrate of soda, during the growing season. These trees made the best growth of any on the farm, but each winter had more or less of their wood killed, and never carried any fruit buds alive through the winter till we quit applying the soda.

The third question was sought to be answered by planting nearly 200 trees on a flat tract of land, not lowland, but on an elevated plain, surrounded by many acres of similar flat land, no chance for frost to drain off quickly. Result: fruit buds killed almost every winter, only one crop of fruit in eleven years, while trees on a side hill, less than 100 rods away, have borne four good crops in the same time.

The fourth question was answered by, for three seasons, leaving a small block of trees unwashed. As a result 90 per cent. of the trees were infected with borers, while of trees washed annually, over 90 per cent. were free from the pest.

While on the subject, might just as well clear up the matter of borer wash. After the first three years and our orchard had grown larger, we quit using the soft soap and substituted caustic potash, as the only object of the soap was to smooth the bark, that there might be less chances for rough places for the mother beetle to deposit the eggs which hatch out and make the borer.

Potash answers the purpose just as well. We also add white arsenic, as it makes good feed for mice and rabbits that may happen to try to live on peach bark. Some clay or fresh cow dung is also put into the mixture, as it helps it to adhere to the tree better than when lime alone is used. We make so much of the wash that it is hard to give a receipt for a small quantity. For a fifty gallon cask, twenty-five pounds caustic potash, three pounds common white arsenic, two gallons of crude carbolic acid, with water, lime and clay enough added to make a good thick wash that will last on the trees three or four months.

II.

The main block of 3,000 trees put out the second season were planted 15 by 15 feet, except a few that were planted 15 by 12 feet, not so much for experiment as to match a pear orchard adjoining. Thorough cultivation with an Acme harrow, worked by two horses, was given both the one and two year old orchards up to midsummer, except on a section of an acre or so where we had planted raspberries between the trees. Here they made a less rapid growth, and culture was kept up till into September. In the fall they were all banked up same as the first season. In fact, it has since been a practice to bank all trees each fall for the first three years. Mice and rabbits seldom trouble older trees, and after they arrive at that age their roots are sufficient to brace them against the wind.

The following spring in trimming the two year trees it was found that our close shortening in the previous spring was having a tendency to form rather too close, compact a head, and much "slashing" had to be done to let in sufficient daylight. After this thinning out, the main branches were headed back from one half to two thirds of the new growth, aiming to cut just above buds that were so situated as to start out in the right direction to fill in the top, make a well shaped head and not crowd others. When it came to trimming the yearling trees, profiting by experience with the others, the head was broadly opened up by a most thorough thinning out, and then the main branches were shortened in, but just a very little. Aftergrowth showed this to be the right practice, and we now follow it up. Then after the second year shorten in one half to two thirds of almost all new growth, using judgment as regards each individual tree.

As to time of pruning, we do it any time from as soon as a man can stand it to work in the field in February or March up to the middle of May, the latter being the best time if trees are inclined to make a too rapid wood growth. Young trees, three to five years old, often having set a small crop of fruit, will drop it all, when trees make a great amount of new wood. To check this, trim the trees when two thirds leaved out, and new growth will be so checked as to allow the trees to perfect all their fruit. However, for trees not over-thrifty, trimming should be done before any signs of new growth in spring. Yet our liberal manuring and culture has always given very thrifty trees, and after they have come to a bearing age, none of the shortening in has been done till after the fruit buds began to show signs of life in April, then if all were dead we trimmed very close, that they might be in all the better shape for next year. If there were many live buds and indications of a full crop, we shortened in and thinned out the wood quite severely as the quickest way of thinning the fruit as well as benefiting the trees, while on the other hand if there were but few live fruit buds, we would not trim till they were well developed, so that we could see them all, then trimmed only when we could do so and not cut away many of the fruit buds, all of which were required to make a fair crop.

This plan has not resulted in uniformity in the orchard, but, what is of more importance, has made the venture a paying one.

In 1880 the 3,000 trees on the home farm were looking so well that it was decided to extend our plantings if suitable land could be rented, as all on the home farm that was thought satisfactory had been taken up. After considerable looking about, a fifteen acre patch of poor, run-down sandy loam land was found that was high and dry, and near it were deep valleys to drain off the frost rapidly, this being to my mind a very important point in peach culture at the North, where most failures of the fruit crop come from winter frosts killing the fruit buds.

This land was rented for a term of ten years, we paying six per cent. annually on a liberal selling price of the land. On this was planted 2,800 more trees 15 by 15 feet in 1881, and in 1884 another tract was leased for fifteen years on same terms and 5,700 more trees planted, one half the field 18 by 18 feet and the other half 12 by 12 feet. On all of these orchards similar methods of planting, pruning, manuring, and cultivation have been followed, and with the exception of the small patch of raspberries referred to, the trees have had the whole use of the land.

After the second year the fertilizers were spread broadcast all over the ground early each spring, the land plowed shallow, and then kept free from weeds with harrows and a single horse cultivator to work close to the trees. Every year, whether we had any fruit or not, the orchards have had from 1,000 to 1,200 pounds of fine ground raw bone and 300 to 500 pounds of 80 per cent. muriate of potash per acre, each applied separately early in the spring.

The distribution has not been equal. Sandy sections have received more potash than where the soil was heavy loam. Bone has been applied heavily where trees appeared to lack vigor, while where a very rapid growth was taking place less was put on, always keeping my eyes open in the growing season.

I have been able when carting on the fertilizer in the spring to drop the bags just where I wanted them and spread accordingly. In this way have been able to feed the trees just what they appeared to require, which could not have been done with mixed goods.

Have at all times kept on hand a small stock of nitrate of soda to apply around any trees that show a lack of vigor or are troubled with leaf curl early in the season. This soda acts so promptly and energetically that most trees have responded to it at once, and gone on all right when followed up with an extra allowance of bone and potash. The reason nitrate of soda is used in preference to any other form of nitrogen is because of its quick action and non-lasting qualities.

Other forms of nitrogen would keep the trees growing too rapidly late in the season, which is not advisable, either for the sake of the wood or fruit buds, and even the soda should not be applied later than June, for while we do not as yet know the real cause of the yellows, I am satisfied that a tender wood growth caused by the use of nitrogenous manures puts the tree in condition to be so affected by hard winter freezes that it is far more likely to be struck by yellows than a tree grown with but little nitrogen.

The question of cultivation in the orchards has been one of more or less study. The fields must be plowed once each season, and then kept soft, mellow, and free from grass or weeds through the growing season. While the trees were small there was little trouble. But as they grew larger the roots filled the whole soil, and the low-headed trees spread out over the ground and trouble began. There was little trouble in turning the earth toward the tree, but to turn it away was another matter. Then again it was difficult to teach men to plow shallow and not tear up the roots. One thing was decided upon, whiffletrees must be dispensed with. Therefore Croffut's horse yoke, Sherwood and Mason plow harness were each in their turn tested, and after throwing away the high hames that came with the latter, and substituting low-top, close-fitting iron hames, Mason's was adopted as the perfection of a plow harness for working among trees.

A light, short, stubby plow, with short upright handles, that allowed a man to run a plow out or into the soil quickly when passing trees, and the beam so rigged as to be quickly moved six or eight inches one way or the other was adopted, and with the rigging and a rather light pair of horses, most of the orchards were annually plowed shallow in large "lands" instead of an independent job between each row of trees, and thus ridges and furrows were avoided. In plowing with a right hand plow it was plain sailing till within three feet of a row of trees, then the beam was shifted so as to throw the point of the plow toward the tree, that the horses might be kept far enough away not to do harm.

The next time around the draught chain was let out fifteen to eighteen inches and a second furrow was cut away without trouble. The third and last furrow on that side of the row of trees requires judgment and skill on the part of the plowman to complete at one trip, and it is often found best to make one more trial to finish up in good shape. Passing to the other side of the row, shift the plow beam to the left, and once around with the long draught chain shorten this up second time around. Third time bring plow beam into place, and it is straight ahead work till within three feet of next row of trees.

Of course, in working out lands, care was always taken to keep the same distance from the rows when going up and down the field, and thus save beam and chain shifting. Cross harrowing with an Acme harrow and sometimes a single horse cultivator once in two or three weeks, till it was time to quit in August, made up each season's cultivation, except now and then a little hand hoeing to kill grass or weeds at the base of the trees where the cultivator had failed to connect.

This was the annual programme up to two years ago, when a test of Clark's Cutaway harrow convinced us that this would mellow the ground as deeply as we cared to plow, and avoid all danger of tearing and breaking the roots. So plowing was abandoned, and for the past two years the Cutaway harrow has been substituted for all other tools. The work has been better done except in a few rough places and the expense reduced one third, which is quite an important item where thorough culture is given, and thorough culture must be given if extra fruit is wanted.

III.

In our low heading of trees, while knowing it would give better fruit and reduce the cost of trimming trees, thinning and picking fruit, I at first had my doubts about being able to use horse power to good advantage in cultivation. Experience has shown that starting the trees headed low has a tendency to cause the outer limbs to grow upward as well as outward in such a way that horses can crowd up against them without injury; while in higher headed trees the limbs are often inclined to grow downward as well as outward, and unless they are high enough to clear horse's head and back, it is difficult to get near them without doing considerable harm.

Of course, the cleanest and best cultivation can be given trees that are headed seven feet or more high. But as between one headed four to five feet up or one branching 18 inches to two feet from the ground, give me the low-headed one. From time to time it has been, of course, necessary to cut off the few outside branches that would persist in growing directly outward, yet on the whole very few of any size have had to be cut away, and the advantages of the low-headed trees have far more than compensated for this slight loss.

Just a word now about raspberries or other such stock in the peach orchard. At the end of the second year that small part of the home orchard that had been planted among the raspberries showed much less vigor than the rest of the orchards, although a double ration of manure had been applied, as we thought, enough for both crops. The third year a portion of the raspberries having been winter-killed were rooted out, and the trees made a new start and went on all right; but it was at the end of five years that we rooted the rest out. Some few of the peach trees had died, and the others were not one-half as large as those of same age that had been given the full use of the land. However, they improved somewhat after the raspberries were removed; but it is a fact worth noting, the first case of yellows we had among trees that had plenty of potash was in that block of trees, and now with the home orchard twelve years old, ninety per cent. of what trees we have lost from yellows (excepting the block that never had potash) has been on the field where we attempted to grow some other crop with the peaches.

Of course, our liberal method of manuring, thorough culture, and obtaining no other crop from the land makes peach culture here rather expensive, and as we were not capitalists, these orchards used up all the money we could make from our small fruits and nursery business, besides considerable borrowed from the banks from time to time to pay for fertilizers; so that when we secured our first paying crop of fruit in 1887 the orchards were in debt to us $9,000.

The winter killing of the fruit buds the four previous years in succession had discouraged our friends, and we were urged to abandon "a hopeless enterprise," and not "sink any more money," but as there was no general sign of yellows, and it was real fun to see the trees grow, we had no intention of abandoning the business as long as we were sure of success *if* we could live long enough.

Possibly the figures of cost on one orchard may be of interest to some would-be planters. Here is the account of a twenty-three acre orchard planted in 1884:

Rent, 6 per cent. on a valuation of $30 per acre	$41 40
Plowing, 16 days, man and pair of horses, at $4	64 00
5,700 medium trees, 3 to 3½ feet, del. on lot, $3.50 per 100	199 50
2,810 pounds muriate of potash	56 23
10,000 pounds fine ground bone at $35 per ton	175 00
Cost of trimming and planting trees, 8 men 3 days, at $1.50, 1 team, at $3	39 00
Borer wash, $4.75; application of same, $4.75	9 50
Summer pruning, rubbing off sprouts, etc., 6 days, at $1.50	9 00
Summer cultivation, 5 harrowings, 4½ days each, at $4	90 00
Banking up for winter, 7 days, at $1.50	10 50
Making a total cost of	$694 13

$30.18 per acre, or a fraction over 12 cents per tree at the end of first year.

EXPENSES SECOND YEAR.

Land rent	$41 40
16,345 pounds bone, at 1½ cents	245 17
7,400 pounds muriate of potash at 2 cents	148 00
Cartage on fertilizer, $10.50; application of same, $7.50	18 00
Plowing, 13 days, at $4	52 00
Trimming trees, 31 days, at $1.50	46 50
Borer wash and application	10 65
Summer harrowing, 23 days, at $4	92 00
One horse cultivator, 6 days, at $2.75	16 50
Hoeing around trees, 4 days, at $1.50	6 00
Banking trees for winter, 8 days, at $1.50	12 00
Total cost, second year	$688 22

$29.92 per acre, or a slight fraction over 12 cents per tree.

EXPENSES THIRD YEAR.

Land rent	$41 40
12½ tons bone, at $30	375 00
5 tons muriate of potash, at $42	210 00
Cartage and application of fertilizers	29 75
Plowing, 21 days, at $4	84 00
Driver for plowman	21 00
Trimming, 68 days, at $1.50	102 00
Borer wash and application	19 00
Summer cultivation	117 00
Examination of every tree for borers, 20 days, at $1.50	30 00
Banking trees, 13 days	19 50
Total cost third year	$1,048 65

$45.59 per acre, or about 18½ cents per tree.

The figures of the fourth, fifth, and sixth years are practically the same as of the third, except that the Cutaway harrow having done away with the spring plowing the last two seasons, there is a saving of some $50 on that operation.

The total cost of this orchard up to January 1, 1890, with interest account added, was $5,684.90. It has produced one crop of fruit of 6,695 baskets that sold for $9,666.91, and is now in perfect condition for future good work.

(To be continued.)

OBSERVATIONS OF SATURN AT THE DISAPPEARANCE OF THE RING.

IN a memoir "Sur la variabilité des anneaux de Saturne," published in the *Bulletin Astronomique* (vol. ii., p. 28), M. E. L. Trouvelot touches on some interesting phenomena that he observed in 1877-78, before, during, and after the passage of the sun and earth across the plane of Saturn's rings. On May 18, 1877, M. Trouvelot remarked that the illuminated surface of the ring appeared notably less luminous than the planet; further observations confirmed this, and left no doubt that its relative light diminished up to the passage of the sun across its plane. It was also observed that the color of the light of the ring appeared yellowish and slightly orange when compared with that of the planet, whereas observations made between 1872-76 indicated that the planet was of a yellowish color when compared with the ring. The two sets of observations are thus diametrically opposed to each other; and it appears that, when the height of the sun above the plane of the ring is reduced to 4° 30′, the surface of the latter gradually diminishes in light with the approach of the sun to the plane, and afterward the opposite surface increases in light intensity until the angular distance of the sun from the plane of the ring is again 4° 30′. The cause of this diminution and increase is not well known. It may be due to the change in the angle of incidence of the sun's rays, and, therefore, in the amount of light reflected or to the absorption of the sun's rays by the atmosphere belonging to the rings or to many other causes.

From October 6, 1877, when the sun was 1° 49′ north of the plane of the rings, to February 6, 1878, when the sun crossed the plane, the illuminated surface gradually decreased in width until it appeared as a thin line difficult to recognize, because of its extreme tenuity. It was observed that the decrease in the width of the illuminated ring appeared to be produced by a shadow slowly obscuring it, and M. Trouvelot attributes the shadow to the existence of a zone elevated above the general level of the ring and slightly inclined toward the planet. To produce the observed phenomenon, a protuberant zone on the ring B, and 6,000 kilometers from its outer edge, would have to have an elevation of about 400 kilometers above the plane of the rings: that is, if the north and south surfaces are symmetrical, the thickness of the zone would be 800 kilometers. In consequence, however, of the position of the zone on the ring B, and 25,600 kilometers from the edge of A, the better half of it is generally invisible. Hence in practice the thickness may be said to be 400 kilometers, or nearly 249 miles.

Prof. A. Hall has a short note on "The Thickness of Saturn's Ring," in the *Astronomical Journal*, No. 222, and develops the equation by means of which it may be determined. He also notes that Dusejour gives a value equivalent to 958 English miles in his "Traité Analytique," t. ii., p. 127 (Paris, 1789), as the result of a discussion of the disappearances and reappearances of the ring observed before 1789. Herschel, by comparing the thickness of the ring with the apparent diameters of the satellites, found the value 856 miles (*Phil. Trans.*, vol. lxxx., pp. 6 and 7, 1790).

Schroeter found the value of 539 English miles from measurements of the width of the trace of the ring on the ball of the planet ("Kronographische Fragmente," pp. 157 and 211, Gottingen, 1808).

W. C. and G. P. Bond, by comparing the amount of light received from the surface of the ring a short time before disappearance with the light received from *the edge of the ring*, found the value < 43 miles.

With respect to this latter value M. Trouvelot remarks: "Mais Bond, qui ignorait que le système des anneaux de Saturne n'est pas plan, et que c'est à une assez grand distance de son bord extérieur qu'il atteint son maximum d'épaisseur, ne pouvait arriver qu'à une évaluation erronée et trop petite de cette épaisseur."

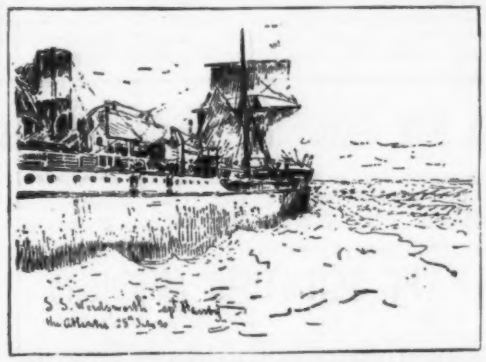
Several other points are touched upon in M. Trouvelot's memoir, viz., that Cassini's division appeared more visible on the eastern side of the planet than on the western, when the elevation of the sun above the plane of the ring was between + 0° 45′ and + 0° 27′; and that the edge of Saturn, like that of Jupiter, was notably more luminous than other parts of the globe. The difference in outline between the preceding and following parts of the ring, the deformation of the limb of the planet at different dates, and many observations possible during the disappearance of the ring are also considered.

The memoir concludes with some remarks and suggestions on the observations that should be made during 1891-92. The next disappearance of the ring is on September 22, 1891, and it will reappear on October 30 of the same year. Again, in May, 1892, Saturn will be well situated for observations on the structure of the rings causing the shadow noticed in 1877-78. It is to be hoped, therefore, that the increased powers now at our disposal will enable many of the questions raised by M. Trouvelot to be definitely settled.—*Nature.*

AN OUTSIDE PASSENGER AT SEA.

By Sir E. J. REED, K.C.B., M.P., etc.

DURING a recent passage from Buenos Ayres to this country in the steamship Wordsworth (Captain Hairby), my friend, the distinguished marine painter, Chevalier De Martino formed the idea of sketching the ship, as she forced her way through the sea, from a point of view altogether outside of the vessel. In pursuance of this idea, he was fortunate enough to persuade Captain Hairby, who happened to be himself an old friend of Chevalier De Martino, to rig out for him a ship's ladder twenty-four feet long, projecting outward at right angles to the side of the ship. This ladder, being well stayed and braced, had placed upon it a chair, protected with a canvas shelter, in which chair De Martino took his seat, and made numerous sketches of the ship which bore him along under such remarkable circumstances. The chevalier tells me that, notwithstanding his having spent years at sea as an officer of the Neapolitan marine, he has never before witnessed or conceived any marine spectacle so splendid as that presented by the ship and the sea from his novel point of view. Never before had he seen water present such fascinating forms and colors as it then presented to his view as the ship bounded along. The position of the ship at the time was that of the mid-Atlantic, about six hundred miles north of the equator. In order to convey more clearly to the eye of your nonnautical readers the position from which the artist made his observations, I have induced him to favor me with the inclosed sketches for your use.



THE STEAMER WORDSWORTH, AS SKETCHED BY THE CHEVALIER DE MARTINO.

No. 1 shows the artist's chair situated at a distance of twenty-four feet from the ship, and No. 2 is a rough sketch of the appearance which the ship and sea assumed from this position. Such sketches can do no more, of course, than convey general and colorless ideas, but we may possibly have an opportunity later of realizing the circumstances more thoroughly, as the chevalier has been persuaded to paint a picture or two from his sketches taken as described, when he shall have the leisure to do so.—*London Graphic.*

SUCCESSFUL SWIMMING OF THE ENGLISH CHANNEL.

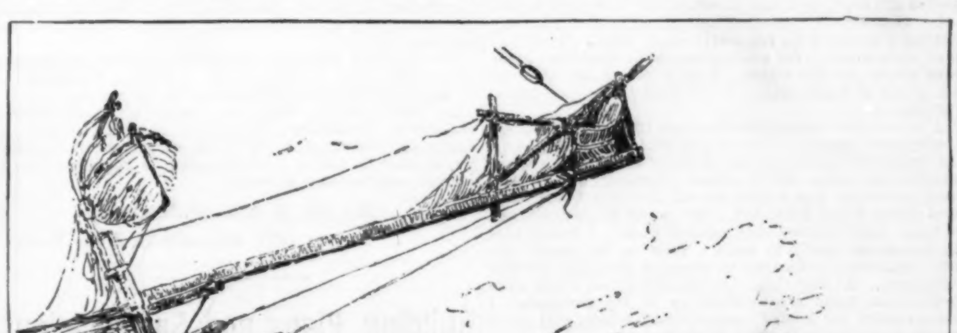
ON August 18 Davis Dalton, the American back swimmer, accomplished his projected swim from France to England, landing on the beach at Folkestone at 3:28, about a thousand yards on the west side of the new Victoria Pier. The scene at the landing was one of great excitement. Dalton was thoroughly exhausted and dropped down in a faint. He had been seen for a long time before he touched land, and a large number of boats gathered round him, while thousands of people congregated on the beach.

Dalton was accompanied by Captain Henry Dunn, who acted as his pilot on the lugger lifeboat Ocean King. The swim is the longest which has been accomplished in the Channel, the distance traversed, allowing for the drift of the tides, being about 60 miles. Dalton covered it in two ebbs and two floods, being in the water altogether 23 hours and 28 minutes, and swimming nearly the whole distance on his back. At 4 P. M. on Sunday, Aug. 17, the weather being extremely favorable, Dalton jumped off the stern of the Ocean King about a hundred yards from the head of Boulogne Pier, the flood tide taking him toward Cape Grisnez. He continued swimming with the last of the flood tide till he had nearly come abreast of Cape Grisnez, when he had to contend with a strong ebb tide setting very fast to southwest. He was apparently swimming quite easily, aided by one or two short rests. At 6 P. M. he was still proceeding with the ebb tide, going with a strong, steady stroke with his legs, never, even when resting, having been in any other position than on his back. At 7 o'clock Dalton was swimming well and asked for some refreshment. He took a cup of bovril, made hot by means of a spirit kettle. The weather was beautiful and the sea comparatively smooth. Very slow progress was made off Cape Grisnez on account of the strong tide.

"PROFESSOR" DALTON—TWO HOURS AFTER LANDING.

The night was extremely cold, and small quantities of bovril were frequently taken by Dalton. Cape Grisnez still bearing northeast by east at 10:30, the rate of progress improved. Dalton was still cheerful, and his leg strokes were firm and strong and slightly quicker. At 1:30 A. M. Dalton was getting away from Cape Grisnez and drawing toward the east end of the ridge. The weather had improved and the water was smooth, but very cold for the time of the year. At 2 A. M. Dalton was making very little progress, and took some more beef tea, saying he felt very tired and cold. At 3 A. M. a shower of rain came on, prior to which Dalton had a long rest, lying on his back in the water, spread eagle fashion. At four the day began to dawn, and Dalton, though swimming fairly well, had drifted, and continued to drift, a long way eastward. The sea being very cold, he took small quantities of beef tea frequently. His rests in the water usually lasted about ten minutes.

At 6:30, after a hard struggle, Dalton reached the Varne lightship, when he evidently was pretty well fagged out. He had been in the water about 14½ hours, during which time both the sea and the wind had been decidedly cold. There had been a good deal of thunder and lightning, with occasional rain. Being spring tides, Dalton had some hard work to do in battling with them. At 7:30 the ebb tide was setting west from the Varne at a great pace. Squalls of rain were frequent, the sea and wind being very cold. At 9:30 Dalton was setting fast toward Hythe with a strong current. About 10:20 he rested for ten minutes and complained of the coldness of the water, but started



SEAT FOR SKETCHING AT SEA.

off again much refreshed, showing very evident signs of fatigue.

At 11:30 Dalton, very much exhausted, was supplied with more bovril, his strokes appearing very much weaker. At 12:15, just off Hythe, Dalton, very much exhausted, had a short rest, and then proceeded, having now got the benefit of the flood tide. At 2:30 Dalton was abreast of Sandgate, and in a terribly cold and exhausted condition. At three o'clock Dalton was gradually getting weaker and taking longer rests, until it was quite painful to see him in the water. When spoken to he only said, "I am done up." About this time he used the breast stroke a little. His face had now a semi-livid appearance. When within a quarter of a mile from the shore Dalton swam quite powerfully again, and struck the shore at 3:28, amid the loud cheering of the spectators.

Dalton is an American, having been born in New York in 1851. He has had great experience in swimming for the last twenty-five years, and has had long distance swims in the Pacific, Atlantic, Bay of Biscay, German Ocean, and the rivers Amazon and Mississippi, but he does not appear at any time to have swum for wagers. Eighteen months ago he came to England with the special object of training for his big swim. Three months ago he went to Folkestone, since which time he has subjected himself to a severe course of training, rising at four o'clock in the morning and entering the sea for a two hours' swim, besides spending eight hours a day in the Folkestone Swimming Baths. In addition to this, he took long walks from six to eight miles daily. Dalton is a thick-set, muscular man, having powerful thighs and chest, and is about 5 ft. 5 in. in height.

AN INTERVIEW WITH "PROFESSOR" DALTON.

"I am an American by birth, though my father was German and my mother Italian. They left me a little money, which I have spent in travel. I have swum in many seas—the Atlantic, the Pacific, the Bay of Biscay, the Mississippi; but the worst of all is this Channel of yours; the undercurrent is fearful."

"Why did you do it?"

"Well, for the sake of doing something that has never been done before. Two years ago I made up my mind to do a special feat and win a reputation. Three weeks ago, you know, I jumped from the Ostend boat, and was nearly sucked down under the swish. About yesterday's swim. I left Boulogne at 3:40. What tried me most was the great difference of heat in certain parts of the water—here 46°, there 50°, again 55°, and again 60°—that and the enormous quantity of jelly fish, which stung me fearfully. After I have been an hour in the water I can do ten times as much as when I first get in."

"Why did you do it on your back?"

"Well, no one else has ever done it, and again, I want to show people that they are perfectly safe on their backs. It takes a great deal of balancing at first. Then, again, I found that it is wonderfully restful to fold one's arms behind one, and lie back upon them. I want to bring it to pass in every board school in England that children shall be taught to float, and that they can learn that it is possible to keep one's self afloat for any length of time on the back. I have taught many to swim in that way."

Here Mrs. Dalton, a pale, sweet-faced German woman, whose anxiety the last few days has been fearful, struck in:

"Yes; my husband has taught me and his little girls how to do it well."

"They will say," continued the swimmer, "that I cannot swim on my breast, but I am one of the strongest swimmers in the world that way. Look here," he went on as he bared a mighty breast. "The doctors all say I am of exceptional physique. I have trained twelve hours a day for eleven months. I ate a pound of raw steak every morning, chopped very fine. I take hardly any spirits. What kept me up on my voyage was a special preparation of bovril. Of course, too, I would take hot coffee, but no spirits. The storm did not affect me, it rather helped. The lightning showed me my way. The Cape Grisnez light was invaluable. I don't know what I should have done without it all night. I did sixty miles. Oh, yes; I noticed everything, and could talk to the people in the boat, and I could thoroughly rest myself now and again by lying motionless on my back; indeed, I could never have done it but for the rests. Had I been unsuccessful, I would never have come ashore. This has been a very hurried attempt, as I had to snatch at the first break in the weather. It was a curious thing that during my training I gained 2 lb. regularly each week. That has never been known, for all doctors say a man loses after being much in the water. I will go off an Atlantic liner going 25 knots an hour, for really I do not know what fear is.

"I have a far bigger scheme than this, which I hope to carry out shortly. There was not much sun, and that was much in my favor. I think nothing of swimming twenty miles quite alone. Coming out of the water yesterday was a great shock, I didn't know what I was doing when I landed. So many thousands are drowned now because they cannot float. I hope this will encourage many to learn. That is my great object. Mine was no foolhardy attempt like poor Webb's at Niagara. At any time, and in any place, I will give the London press an illustration of my methods. I hope to swim the Irish Channel soon, which will take me thirty-six hours."—*Pall Mall Budget.*

AMMONIUM CHLORIDE FROM GAS LIQUOR.

IN a communication to the *Bulletin* of the Rouen Industrial Society, MM. Dubosc and Heuzey remark that, in the manufacture of coal gas, ammoniacal liquors are produced which come into commerce in three separate states: (1) as crude gas liquor; (2) as concentrated liquor; (3) as crystallized ammonium sulphate. These three products may be treated with metallic chlorides so as to yield ammonium chloride; the process varying according to the product treated. Gas liquor, whether crude or concentrated, contains besides ammonium sulphate, free ammonia, ammonium chloride and cyanide, a considerable amount of ammonium carbonate and sulphide which renders it impossible to make the chloride directly by the action of hydrochloric acid—the attempt being attended by the disengagement of large quantities of carbon dioxide and sulphureted hydrogen. The authors have a new process based on the precipitation of the sulphur and carbonic acid by double decomposition and a mixture of the chlorides of iron and calcium in proper proportions; neither the sulphides nor carbonates of these metals being soluble in the presence of ammonium chloride. The originality of the process consists in the use of the mixture of iron and calcium chlorides, and it presents the advantage of complete desulphurization and rapid precipitation of the carbonates. In practice, the liquor is allowed to stand for 48 hours so as to free it from tar; and it is then pumped into a tank in the bottom of which the necessary quantity of the mixed chlorides has been placed beforehand. After having been mechanically agitated, the mixture is left for 12 hours to settle. The upper two-thirds of the liquor is then perfectly clear, and absolutely free from sulphide or carbonate. After being slightly acidified if necessary, this portion is piped direct to the concentrating pans. The precipitate, consisting of mixed carbonate and sulphides of iron and calcium, is filtered on horizontal filters, or preferably in a press. The dried residue forms an excellent purifying mass for coal gas; being analogous to Laming's mixture. The liquid in the pans is concentrated to 13° Baumé, when it is drawn off and left to crystallize in wooden troughs, which it does in about 15 days. This process produces acicular crystals; but when cubes are desired, 5 per cent. of a solution of perchloride of iron, of 35° Baumé, must be added to the mother liquor. Ammonium sulphate is also treated by the authors for a similar purpose.

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